SUSTAINABLE ENERGY FOR ALL

UNOPS

UNDERSTANDING MINI-GRID TARIFFS IN SIERRA LEONE

A Quantitative and Comparative Analysis of Price Drivers

SEforALL SDG 7 IMPACT SIERRA LEONE

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3 Abbreviations

AfDB	African Development Bank
AFUR	African Forum for Utility Regulators
AMDA	Africa Minigrid Developers Association
BNEF	Bloomberg New Energy Finance
CAPEX	Capital expenditure
CEI	Clean Energy and Energy Inclusion
CHC	Community Health Centres
CoSS	Cost of Service Study
DART	Demand Aggregation for Renewable Technology
ECOWAS	Economic Community of West African States
EDSA	Electricity Distribution and Supply Authority (Sierra Leone)
EPA	Environmental Protection Agency
ERERA	ECOWAS Regional Electricity Regulatory Authority
ESMAP	Energy Sector Management Assistance Program
FCDO	Foreign Commonwealth and Development Office, UK
GoSL	Government of Sierra Leone
GBP	British Pound Sterling
GEAPP	Global Energy Alliance for People and Planet
GMG	Green mini-grid
IRENA	International Renewable Energy Agency
IPP	Independent power producer
IRR	Internal Rate of Return
kW	Kilowatt
kWh	Kilowatt hour
LCOE	Levelized cost of energy
LCPDP	Least cost power development plan
M&E	Monitoring and evaluation
MST	Minimum subsidy tender
MW	Megawatt
MYTO	Multi Year Tariff Order
NDA	Non-disclousure agreement
NEP	Nigeria Electrification Project
NERC	Nigerian Electricity Regulatory Commission
NGO	Non-governmental organization
O&M	Operating and maintenance
OEM	Original equipment manufacturer
OPEX	Operating expenditure
PAYG	Pay-as-you-go
PBG	Performance-based grant
PPP	Public-private partnership
PV	Photovoltaics
RBF	Results-based financing
REA	Rural Electrification Agency
REF	Rural Electrification Fund
RMI	Rocky Mountain Institute
ROE	Return on equity
ROI	Return on investment
RREP	Rural Renewable Energy Project
SDG	Sustainable Development Goal
SEforALL	Sustainable Energy for All
SL	Sierra Leone
SLEWRC	Sierra Leone Electricity and Water Regulatory Commission
SLL	Sierra Leonean Leone
ToU	Time of Use
UEF	Universal Energy Facility
UNOPS	United Nations Office for Project Services
USAID	United States Agency for International Development
VAT	Value added tax
WACC	Weighted average cost of capital
WP	Work package

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5 Executive Summary

Sierra Leone has one of the lowest electricity access rates in the world; the country has a national electrification rate of 26 percent, although this figure declines to just 6 percent in rural areas where the majority of the population lives. The Government of Sierra Leone (GoSL) has, over time, made important policy and regulatory enhancements to support initiatives to increase electricity access, some of which have been supported by international development partners such as the UK Foreign, Commonwealth and Development Office (FCDO).

The Rural Renewable Energy Project (RREP) funded by the FCDO has supported technical assistance and capacity building to GoSL institutions and the private sector to establish an enabling environment for market-driven mini-grid development and long-term sustainable mini-grid operations. Under the RREP, private sector-market driven mini-grids will supply up to 5 MW of renewable electricity to Sierra Leone's rural communities. Three private sector mini-grid operators, Winch Energy (SL), Off-Grid Power (OGP/ PowerGen) and Power Leone (Energicity) are engaged in a public private partnership (PPP) with the government to maintain and operate mini-grid systems installed with RREP co-investment. Through the RREP, the Sierra Leone Electricity and Water Regulatory Commission (SLEWRC) issued the 2019 Mini-Grid Regulations, now ratified by parliament, to simplify mini-grid regulations and establish a tariff setting framework. These regulations also provide for cost-reflective mini-grid tariffs. SLEWRC has applied these regulations with its tariff calculation tool to approve tariffs for mini-grids operating in the country. Various subsidies as well as the removal of the goods and services tax (GST) on operators have been provided to reduce end-user tariffs and increase affordability and therefore access. Despite the various incentives and significant effort by the government and donors alike to develop an enabling environment for mini-grid electrification, the end-user tariffs remain comparatively high and have resulted in concerns around affordability of mini-grid electrification for rural customers in the long-term.

This report provides results of the analysis of the Sierra Leone mini-grid tariff cost buildup and practical recommendations for interventions to reduce end-user tariffs and improve the affordability of mini-grid electrification in rural areas. Tariff reduction will be achieved through enhanced efficiencies and reduced barriers along the value chain, spanning from service territory allocation to the end-user tariff settlement. To come up with these recommendations, this study analyzed the various components that make up a tariff in Sierra Leone and the tariff calculation tool used by the SLEWRC. It also consulted various mini-grid stakeholders in the country, and conducted a comparative analysis of tariff parameters in another market in the region, Nigeria. Nigeria was chosen because along with Sierra Leone it signed the mini-grid compact with the FCDO to grant comparable mini-grid subsidies to developers. In addition, Nigeria and Sierra Leone use a similar five-year multi-year

tariff order (MYTO) developed by the same consultant to calculate their mini-grid tariffs in the same manner. At the beginning of the study, it was also discovered that there were useful lessons to be learned from Nigeria's Rural Electrification Agency (REA) which, in 2018, undertook the "20 by 20" initiative, aimed at reducing its mini-grid tariffs to USD 0.20/kWh by 2020.

This analysis builds on Sustainable Energy for All's (SEforALL's) 2021 report, *Increasing Energy Access in Sierra Leone*, which was funded by the FCDO. The objective of the 2021 study was to inform the way forward for access to energy in rural Sierra Leone, with a focus on mini-grids, grid-connected rural communities and other off-grid solutions. Some of the areas covered in the study include, but are not limited to: the criteria to determine whether an on-grid or off-grid supply is most appropriate for a particular location; the criteria for planning more broadly across the energy sector in Sierra Leone to achieve Tier 2 energy access and above, involving both supply-side and demand-side factors; and the potential and applicability of mini-grids with solar PV in the context of Sierra Leone's agricultural sector as an important starting point for looking at electricity access strategies from a multi-industry, multi-sector and gender-inclusive perspective.

Summary of Main Findings

Sierra Leone's mini-grid tariffs range between USD 0.74 and USD 0.82/kWh (SLEWRC approved rates, 2020–2021 down from between USD 0.82 and USD 0.87/kWh for 2019-2020[1]). In Nigeria the cost of mini-grid tariffs ranges from between USD 0.30/kWh (subsidized) and USD 0.90/kWh (unsubsidized).

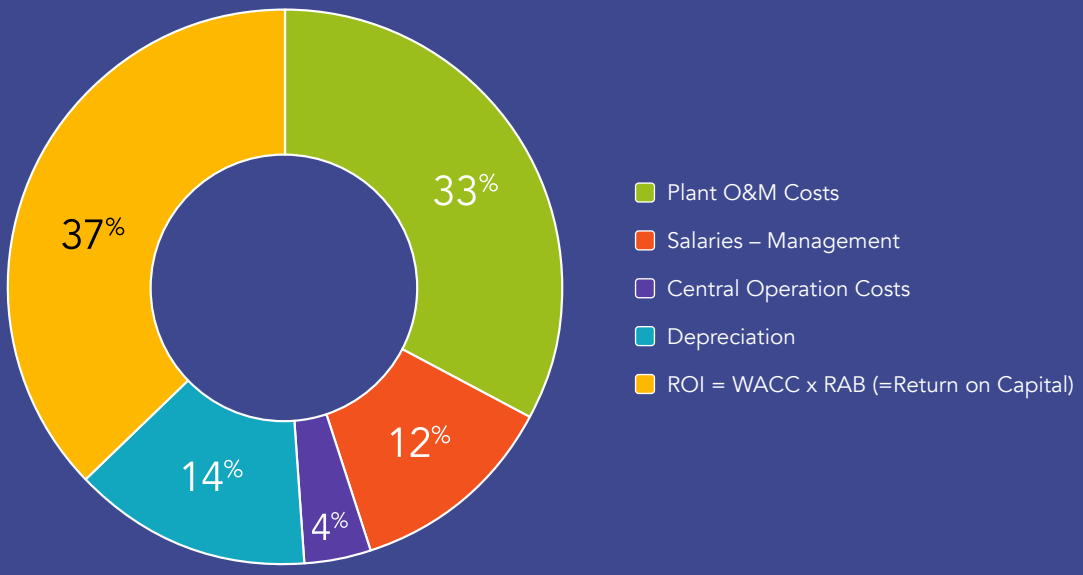
The three private sector mini-grid operators, Winch Energy (SL), Off-Grid Power (OGP/PowerGen) and Power Leone (Energicity) engaged in a PPP with the GoSL were selected through a competitive bidding process. These operators were selected for the technical and commercial operation of all power generation and distribution assets with the aim of generating revenues from electricity sales to the communities.

A mini-grid tariff in Sierra Leone is calculated on a "cost-plus" basis that enables operators to recover all costs to provide the electricity supply service and allows for a return on investment (profit) commensurate with the investment risk. Figure 1 shows the three operators' average cost elements that build up to the end-user tariff. The two main cost contributors to a tariff are the return on investment (37 percent) and the direct plant operating and maintenance (materials and labour) costs (33 percent).

[1] SLEWRC Annual Report 2021

FIGURE 1

Sierra Leone Tariff Cost Buildup (Average for 3 Developers)



The interventions to support lower tariffs should therefore address these two main cost contributors. Such interventions could bring the tariff to within the range seen in Nigeria of between USD 0.30 and USD 0.57 (the Nigeria median) from between USD 0.74 and USD 0.84/kWh[2] (2020–2021 SLEWRC approved rates). However, the depreciation of the Sierra Leonean Leone against the US dollar may complicate matters as end users pay their tariff in local currency. Hence, while tariffs may be pushed down in US dollar terms, the depreciation of the local currency against the US dollar could erode those gains in real terms when foreign exchange losses are absorbed by the end users.

The two main cost contributors to be targeted are capital expenditure to bring down return on investment, and depreciation charge in the tariff. Performance optimization and adoption of cost-saving technology by developers will help to bring down direct plant operating and maintenance costs. It is also highly probable that unutilized capacity is a major contributor to the tariff differences between Sierra Leone and Nigeria as discussed in detail in Section 12.2 of this report.

Before providing subsidies, stakeholders should agree on a mini-grid tariff that is affordable to the community and acceptable

[2] SLEWRC 2020 Annual Report, Table 4: Tariff Structure.

to both the private and public sectors. The difference between the mini-grid tariff and the cost-reflective tariff is then covered by a sustainable smart subsidy.

Aside from subsidy schemes, there are a range of interventions that should be explored to bring down tariffs in Sierra Leone. Some are regulatory and policy driven while others are operational on the part of developers. They include: localization of frontline support, efficiency improvements, and deployment of proven new technologies for operational performance. In addition, in order to have an impact, the recommendations should be seen as a package rather than as standalone measures.

Recommendations

The following recommendations, some of which are informed by lessons learned from Nigeria, are intended for those in the Sierra Leone mini-grid space who have the ability to effect change.

1. Recommendations under the policymaker's influence

Service territory allocation: The approach taken for the development of new sites must allocate a portfolio of sites to enable economies of scale (bulk procurement) that drive down costs as well as combine more commercially viable sites with rural villages so that mini-grid developers can cross-subsidize between sites. Improving economies of scale will reduce capital expenditure (Capex) and some operational expenditure (Opex) (such as salary and operations costs) on a per kilowatt hour (kWh) basis.

Subsidies: The PPP delivery model used in Sierra Leone can be enhanced by having an upfront consensus between developers and the public sector as to the level of tariff to be achieved and a sustainable level of subsidy to be sought. This upfront consensus would provide clarity on tariffs to be charged for the subsidies provided and help avoid delays and uncertainties during and after project implementation.

Extend the license period from 20 to 25 years: A longer license period translates to longer payback periods, and reduces tariffs through a lower depreciation charge, without affecting returns on investments. Any grid encroachment would be covered under the compensation mechanism provided for in the regulations.

Ability and willingness to pay: Consumers should be supported, through community engagement, to understand what constitutes the alternatives for the purposes of measuring avoided costs used in the willingness and ability-to-pay studies. This will ensure that there is no confusion on "ability and willingness" concepts that may lead to wrong conclusions about consumers' demands and what they can afford. Community engagement could be conducted frequently to reinforce the learning.

2. Recommendations under the regulator's influence

Capital expenditure: Regulators should develop original equipment manufacturer (OEM) benchmark costs against which to evaluate the prudency of project Capex submitted by developers. This will help them address uncertainty on what the actual capital costs for a project should be, while

also recognizing that there are project-specific variations. If there are established international benchmarks, they may be used as a comparative to the internally developed benchmarks for alignment.

Capacity utilization: Market risk should not be allocated to current customers. Unutilized capacity should be excluded from mini-grid tariffs. Developers should use modular designs to mitigate the risk of oversizing.

Opex: This will require action by both the developers and the regulator. Developers should make use of cost benchmarking for testing prudency of operating and maintenance costs in tariffs applications. The regulator should monitor trends in the adoption of new cost-saving technologies such as remote monitoring and support the adaptation of the same in Sierra Leone.

Affordability: The regulator should calculate reasonable mini-grid tariff levels by making a comparison with accurate avoided costs.

Tariff tool currently in use in Sierra Leone: The tariff tool has no obvious area to improve calculations. At the same time, it is not easy for an inexperienced user to review/follow. It therefore requires the regulator to develop adequate capacity for specialists to be able to review applications. While that is happening, the regulator may need to devise a simplified way of conducting a high-level check of the tariff model's inputs and outputs. In addition, feedback from developers indicated that the tool does not make provision to adjust for currency depreciation and inflation over the five-year MYTO period.

6 Objectives & Background

6.1 BACKGROUND

Sierra Leone has one of the lowest electricity access rates in the world; the country has a national electrification rate of 26 percent, although this figure declines to 6 percent in rural areas where the majority of the population lives.

Market potential: The size of the Sierra Leone mini-grid market is estimated to be USD 33 million. This is based on an estimated 2.9 million non-electrified people in Sierra Leone who can best be served by mini-grids. These people have an average electricity consumption of 0.2kWh per household per day. The average cost-reflective mini-grid tariff in Sierra Leone is about USD 0.9/kWh. The per capita annual electricity expenditure within the non-electrified population best served by mini-grids is USD 11.7[3].

Mini-grid regulatory environment: The Government of Sierra Leone (GoSL) has, over time, made significant progressive policy and regulatory enhancements to support initiatives to increase electricity access, some of which have been supported international development partners such as the the UK Foreign, Commonwealth and Development Office (FCDO). The Ministry of Energy (MoE) is responsible for oversight and policymaking while the Sierra Leone Electricity and Water Regulatory Commission (SLEWRC), is responsible for regulating the power sector, including mini-grids. The GoSL's National Renewable Energy Action Plan (2015), National Renewable Energy Policy (2016), National Energy Policy (NEP) (2019) and the National Energy Strategic Plan (2019) provide for decentralized solar power and for mini-grids within the rural electrification strategy to increase access to energy in rural areas of Sierra Leone. The SLEWRC issued the 2019 Mini-Grid Regulations to simplify the mini-grid regulatory and tariff setting framework. The regulations provide for cost-reflective tariffs and allow for two license categories that envisage "a basic mini-grid license;" regulation for projects below 100kW and "a full mini-grid license" for mini-grid projects between 100kW and 10MW.[4]

Key donor programmes in Sierra Leone: Some of the ongoing and completed donor programmes include:

The Rural Renewable Energy Project (RREP) is a GBP 37.7 million project funded by the FCDO that started in 2016. The RREP is implemented by Sierra Leone's MoE with support from the United Nations Office for Project Services (UNOPS). The RREP

[3] Green Mini-Grid Market Development Programme: Sierra Leone Mini-Grid Market Opportunity Assessment, African Development Bank (AfDB) and Sustainable Energy Fund for Africa (SEFA), November 2019

[4] SLEWRC: Mini-Grid Regulations 2019: https://ewrc.gov.sl/mini-grid-regulations/

implementation phases[5] are within developed work packages (WPs) (WP-1 to WP-7) details of which are provided in the Annex. The RREP is establishing an enabling environment for a private sector-driven rural mini-grid market in the country to supply up to 4 MW of renewable electricity in rural communities. At least 94 solar mini-grids will be installed, operated and managed by private sector partners and 97 community health centres (CHCs) will be electrified, building capacity and an enabling environment for mini-grid development. The enabling environment established for a private sector-led mini-grid market includes mini-grid regulations, environmental guidelines for Environmental Protection Agency (EPA) licensing, and a transparent mechanism for establishing cost-reflective tariffs.

The **Energy Access Project** is funded by the World Bank to the sum of USD 52.70 million for the period from 2021 to 2025. It is being implemented by UNOPS on behalf of the GoSL for the Electricity Distribution and Supply Authority (EDSA). The programme has three components: grid extension and cross border interconnection, electrification through mini-grids and standalone solar systems, and capacity building[6].

The **Increasing Access to Renewable Energy in Rural Sierra Leone** programme is funded by the Government of Japan to the sum of USD 3.6 million. It is implemented by UNOPS on behalf of Sierra Leone's MoE to help to expand energy access to remote villages, using solar PV mini-grids to serve six underserved rural communities and benefitting over 15,000 people[7].

The **Universal Energy Facility (UEF)** is a multi-donor results-based financing (RBF) facility established to significantly speed up and scale up energy access across Sub-Saharan Africa, in line with Sustainable Development Goal 7 (SDG7) — access to affordable, reliable, sustainable and modern energy — and the Paris Agreement. The UEF provides incentive payments to eligible organizations deploying energy solutions and providing verified end-user electricity connections (including mini-grids and standalone solar systems) based on pre-determined standards. With this model, the UEF is expected to be a standardized financing vehicle for global off-grid energy developers and aims to become a USD 500 million facility at scale.

In 2022, the UEF paid out results-based grants for 654 electricity connections under its Wave 1 mini-grids programme, with thousands more connections anticipated for 2023 across Benin, Madagascar and Sierra Leone. It also

[5] Phase 1(completed in July 2017) installed solar power in 54 community health centres (CHCs) and network distribution to one school in Conakry Dee, Port Loko District.

Phase 2 (implemented in 2018) expanded 50 of the previously constructed 54 health centre solar power stations and installed distribution networks throughout each village, creating 50 independent mini-grids. These distribution networks extended electricity access to houses, schools and businesses in the various villages. (UNOPS Fact Sheet RREP Updated, June 2021).

[6] https://projects.worldbank.org/en/projects-operations/project-detail/P171059

[7] https://www.unops.org/news-and-stories/news/increasing-access-to-renewable-energy-in-rural-sierra-leone

launched a second wave of mini-grid finance for companies operating in Madagascar and Sierra Leone, and in a newly UEF-supported country, Congo (DRC).

Wave 1 activities in Sierra Leone launched in October 2020 and are currently at the implementation stage. The UEF received 14 project applications from two pre-qualified developers and has signed a grant agreement with one developer that will deliver 1,385 connections in the country by Q4 2023. Construction is expected to commence in Q1 2023[8].

Clean Energy and Energy Inclusion (CEI) for Africa was established in 2021 by KfW on behalf of the German Federal Ministry for Economic Cooperation and Development to improve access to energy for rural households and enterprises in Sub-Saharan Africa. CEI Africa has allocated EUR 21 million that is intended to be used by project developers to finance green mini-grids (GMGs) through RBF grants and includes the provision of technical assistance to GMG project developers. Financing is available to GMG developers in Benin, Congo (DRC), Kenya, Madagascar, Mali and Sierra Leone[9].

Other: "*mini-grid investment programs, initiated by Development Institutions, such as GIZ, ECOWAS, ECREEE, Power for All, USAID, focused first on developing and improving the mini-grid ecosystem. After aligning the policies and regulations, donors, international organisations and financing institutions were comfortable to invest in renewable energy mini-grid projects, with considerable funds allocated to the sector to accelerate the roll-out of mini-grids*"[10]

From April 2020 to March 2021, SEforALL led the **Increasing Energy Access in Sierra Leone** project, funded by the FCDO. The objective of this project was to inform the way forward for access to energy in rural Sierra Leone, with a focus on mini-grids, grid-connected rural communities and other off-grid solutions. In order to expand on the RREP project, this project provided an overview of the following:

- Drivers and barriers of mini-grid solutions in the context of Sierra Leone's existing mini-grid projects, evaluations of the current tariff structure, subsidy models applied to current mini-grid projects, structures in place in support of public-private partnerships (PPPs), and lessons learned from all of these.
- Examples and lessons learned from Nigeria, specifically related to Tier 2 energy access or above and productive use, including the impacts, drivers and barriers in achieving it.
- Other available and possible policy and regulatory options for tariffs, subsidy mechanisms (including results-based payments and auctions with capital subsidies) and management arrangements

[8] UEF Programme Manager, Sustainable Energy for All

[9] https://odysseyenergysolutions.com/cei-africa-launches-a-call-for-applications-and-technical-assistance-window-on-odyssey

[10] Success in Rural Electrification: Sierra Leone, A Cost Reflective Tariff Framework.

for currently unserved communities, covering both grid extension and off-grid supply, including provisions when the grid extends to an existing mini-grid site.

- Criteria to determine whether on-grid or off-grid supply is most appropriate for a particular location, for planning more broadly across the energy sector in Sierra Leone to achieve Tier 2 access and above, involving both supply-side and demand-side factors.
- Potential and applicability of mini-grids with solar PV in the context of Sierra Leone's agricultural sector as an important starting point for looking at electricity access strategies from a multi-industry, multi-sector and gender-inclusive perspective.

6.2 OBJECTIVES

This report provides the results of an analysis of the tariff cost buildup and practical recommendations for interventions to reduce the end-user tariff to address affordability of mini-grid electrification in the long term. It analyzes the different components of the tariff calculation tool and how they impact the end-user tariff across different mini-grid developers from Sierra Leone and comparative parameters from Nigeria. The analysis and resulting recommendations propose opportunities for efficiencies or removing barriers along the value chain that, in the long term, will reduce the end-user tariff, and improve affordability of mini-grid electrification in rural areas of Sierra Leone.

In order to achieve the above objectives, the following activities were undertaken:

a. Analysis of the tariff calculation tool currently deployed in Sierra Leone and in Nigeria.

b. Collection of tariff calculation data from active mini-grid developers in Sierra Leone.

c. Comparison with end-user tariffs from Nigeria's mini-grid market that has similar calculation methodologies.

d. Analysis of how specific elements in the tariff calculation are costed differently between different mini-grid developers and between different markets (e.g., the weighted average cost of capital (WACC); cost of labour; logistics; procurement & contracting.

e. Report with practical recommendations for interventions that can significantly reduce the end-user tariff.

f. Stakeholders' validation of the findings and recommendations.

This research study is focused on isolated mini-grids. It is envisaged that the main findings and recommendations contained in this report will be shared with the key stakeholders including the developers themselves, funders and government officials. This current research builds on SEforALL's 2021 report, *Increasing Energy Access in Sierra Leone*, which was funded by the FCDO. The objective of this study was to inform the way forward for access to energy in rural Sierra Leone, with a focus on mini-grids, grid-connected rural communities and other off-grid solutions. (See Annex for key takeaways on mini-grid tariff frameworks in Sierra Leone and Nigeria from the 2021 study).

7 Methodology

The methodology to undertake this study combined: (a) a participatory consultative approach; and (b) an evidence-based approach. A full description of the methodology is provided in the Annex. The participatory consultative approach entailed holding meetings with the key stakeholders to develop a common understanding of the scope of work, the focus areas, and any other project dependencies. During the consultation agreement was reached on the approach to deliver the assignment. The stakeholders consulted include: the Africa Minigrid Developers Association (AMDA), Cross Boundary, the Foreign, Commonwealth and Development Organisation (FCDO), the Nigerian Electricity Regulatory Commission (NERC), The Rockefeller Foundation, Sustainable Energy for All (SEforALL) and the Universal Energy Facility (UEF).

In the evidence-based approach, mini-grid tariff data were collected from three Sierra Leone developers, in addition to secondary data from relevant reports, building on SEforALL's 2021 report, *Increasing Energy Access in Sierra Leone*, but focusing on findings pertinent to tariffs settlement, ability and willingness to pay. The developers shared their respective raw tariffs data under non-disclosure agreements (NDAs) with SEforALL and these data are presented anonymized in this report.

Once both primary and secondary data had been collected, a systematic framework was applied to analyze mini-grid developers' tariffs. The framework first looked at service territory allocation, the cost components of the capital expenditure (Capex), operating expenditure (Opex), returns on investments determination, and allocation of subsidies. This was then followed by an evaluation of how the tariff is currently calculated, the tariff tool used and the veracity of the tariff tool results. This framework of analysis is comparable to that used in Nigeria in 2018,[11] which shows that Sierra Leone is not alone in exploring strategies to lower the tariffs on mini-grids. Nigeria's Rural Electrification Agency (REA) undertook the "20 by 20" initiative in 2018 aimed at reducing its tariffs to USD 0.20/kWh by 2020.

As a final step, the outcome of the Sierra Leone analysis is compared with tariffs in Nigeria. Nigeria was used as a comparative case for a number of reasons. Firstly, Nigeria uses a similar five-year multi-tariff order (MYTO) developed by the same consultant, making a comparative analysis possible. Secondly, Nigeria is home to a mini-grid

[11] In March 2018, RMI and the Nigerian REA convened leading global experts from across the mini-grid and investment community to identify a pathway to achieving mini grid tariffs of N70/kWh (USD0.20/kWh) by the year 2020. These experts agreed that this is feasible through achievable cost reductions across six categories (hardware, load management, customer engagement, project development, O&M, finance and policy). (Source: RMI and REA, "20 By 20: A Design Charrette to Achieve 20c/kWh by 2020" https://rea.gov.ng/gallery/rea-rmi-rocky-mountain-institute-minigrid-design-charrette/)

market that has spent a comparable amount of effort in crafting a supportive enabling environment for mini-grids as an important technology to reach universal access. While Nigeria is certainly a larger mini-grid market due to the much larger size of the country and economy, it still makes for a useful comparative case, as many in Sierra Leone (government officials and donors alike) have referenced the Nigerian mini-grid tariffs as a benchmark target.

The Nigerian Electricity Regulatory Commission (NERC) was consulted to compare the Sierra Leone mini-grid tariffs with those of Nigeria. The comparative analysis was performed considering the following:

1. The methodology for revenue requirement – based on the cost of service (rate of return). This is an additive (or "cost plus") approach of all cost elements that is used in both countries.
2. The Capex costs – evaluate whether mini-grid assets are comparable in terms of specifications, costs, economic useful lives used for depreciation calculations, and their proportionate makeup in the Capex.
3. The level of value-added tax (VAT) and the impact of import duties on Capex costs.
4. The impact of logistics costs on Capex costs.
5. The weighted average cost of capital (WACC).
6. Subsidies – the levels of subsidies provided and how they are passed on to tariffs.
7. The comparative contribution of operating and maintenance (O&M) expenses to the tariffs.
8. The allowed return on investment comparative contribution to the tariff.
9. The regulatory compliance costs of comparators.
10. Other comparative parameters mentioned in the scope of work.
11. The NERC was also approached to establish if there are "informal" tariff caps that developers think regulators will not approve that lead them to try to keep their tariffs within that "informal" cap.

PART ONE

Introduction

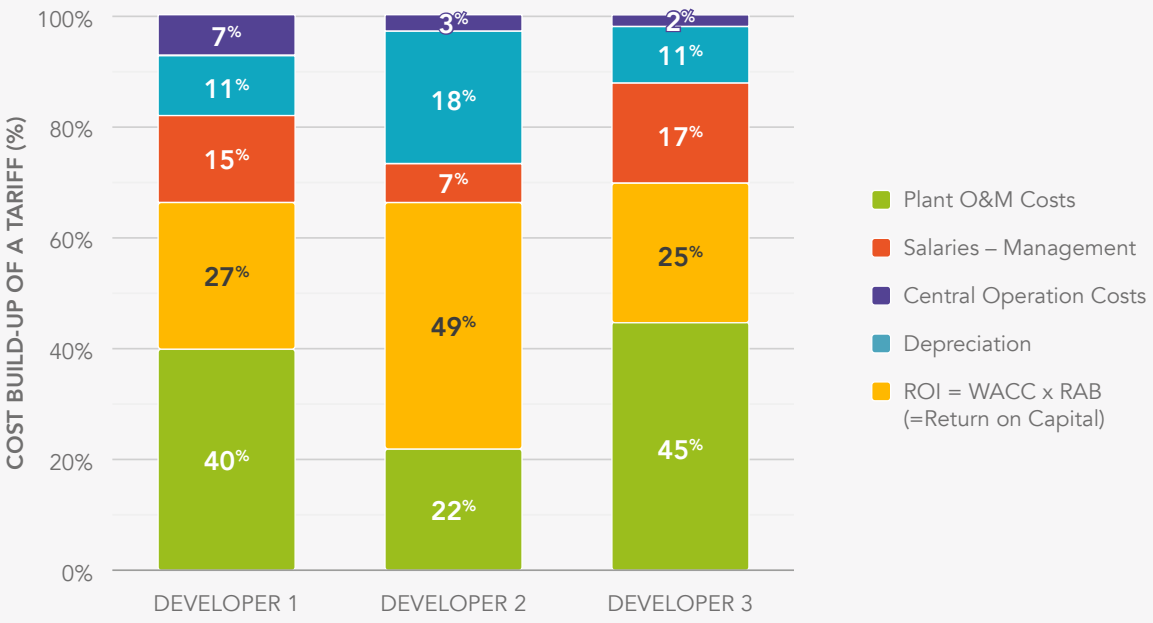
8 An Introduction To Mini-Grid Tariffs

Before delving into the tariffs analysis, it is worthwhile introducing the line items that make up up a mini-grid tariff. A tariff is derived from an annualized sum of: depreciation, return on investment, operating and maintenance (O&M) costs, salaries, and corporate taxes (if not included in the operating costs). This annualized sum is divided by the annualized total energy units generated (or forecast demand) to obtain the tariff per kilowatt hour (kWh). A mini-grid operator can alternatively divide this annualized sum of costs by the number of customers and number of months in a year to obtain a flat monthly tariff per customer.[12] Figure 2 shows the percentage contribution of the various cost elements to the mini-grid tariffs in Sierra Leone.

Using data from the three developers Figure 2 illustrates the various cost elements in their respective tariffs. It shows that the cost structures of developers 1 and 3 are comparable, but those of developer 2 are not. Further analysis is provided later in the report.

FIGURE 2

Elements of a Mini-Grid Tariff



[12] Sierra Leone Mini-Grid Regulations(57(2)(b) prescribes options of tariff structures to be (a) conventional kWh tariffs, (b) flat rate tariffs, (c) power tariffs or (d) a combination of the above.

9 Mini-Grid Operators in Sierra Leone and Nigeria

9.1 MINI-GRID OPERATORS IN SIERRA LEONE

The Sierra Leone Electricity and Water and Regulatory Commission (SLEWRC) has listed on its website five mini-grid operators' licenses as being current/valid. These licenses are held by Winch Energy SL, Off-Grid Power (OGP/PowerGen), Power Leone (Energicity), Solar Era Holdings SL and Power Ned. However, Solar Era has become an independent power producer (IPP) under Serengeti Energy. Of the listed valid mini-grid licensees, only Power Ned provides hydro power. Solar PV is the predominant mini-grid generation technology for four of the five valid licensed operators in Sierra Leone. Full details of the mini-grid operators listed on the SLEWRC website are provided in the Annex. Three solar PV mini-grid developers in Table 1, that maintain and operate mini-grid systems installed with the Rural Renewable Energy Project (RREP) co-investment, were engaged and provided data for the purpose of this study:

TABLE 1

Mini-Grid Developers in Sierra Leone Covered by the Research Study

NAME OF MINI-GRID DEVELOPER	REGIONS LICENSED
Winch Energy (SL)	Koinadugu, Falaba, Bombali, Tonkolili
Off Grid Power (OGP/Powergen)	Pujehun, Kailahun, Bo, Bonthe, Kono, Kenema
Energicity (Power Leone)	Moyamba, Kambia, Portloko

These three developers supply mini-grid solar PV generated power under the RREP to rural communities and community health centres (CHCs). Each developer may have more than one site (i.e., a portfolio of sites). The RREP had a target to provide up to 4 MW of sustainable renewable electricity in rural communities reaching 346,000 direct beneficiaries by the end of May 2022[13]. Power Ned's, the hydro mini-grid, installed capacity is 250kW[14].

[13] UNOPS Fact Sheet, RREP Update, June 2021

[14] http://www.energy.gov.sl/wp-content/uploads/2020/10/Solar-Era-Holdings-Sierra-Leone-Ltd.pdf

9.2 MINI-GRID OPERATORS IN NIGERIA

Nigeria has a much larger number of mini-grid operators. The Nigeria Rural Electrification Agency (REA) has listed on its website about 42 mini-grid firms registered under the Nigeria Electrification Programme (NEP)[15].

Note: This research did not endeavour to establish how many of these 42 mini-grid operators have raised funding and deployed projects). The comparative numbers and total installed capacity in Sierra Leone versus Nigeria in 2019 is given in the Appendix. The scale of operations in the two countries is vastly different given their different population sizes.

[15] https://nep.rea.gov.ng/partners/#MG

10 Mini-Grid Tariffs Charged by Operators in Sierra Leone and Nigeria

10.1 MINI-GRID TARIFFS IN SIERRA LEONE

The tariffs approved by the regulator for solar PV generation mini-grids for 2020–2021, as published in the Sierra Leone Electricity and Water Regulatory Commission (SLEWRC) annual report, range from USD 0.74 to USD 0.82/kWh. The tariff structure is shown in Table 2 and Figure 3. It should be noted that the tariffs for the hydro mini-grid are lower at USD 0.22/kWh.

TABLE 2

Average Mini-Grid Tariffs in Sierra Leone

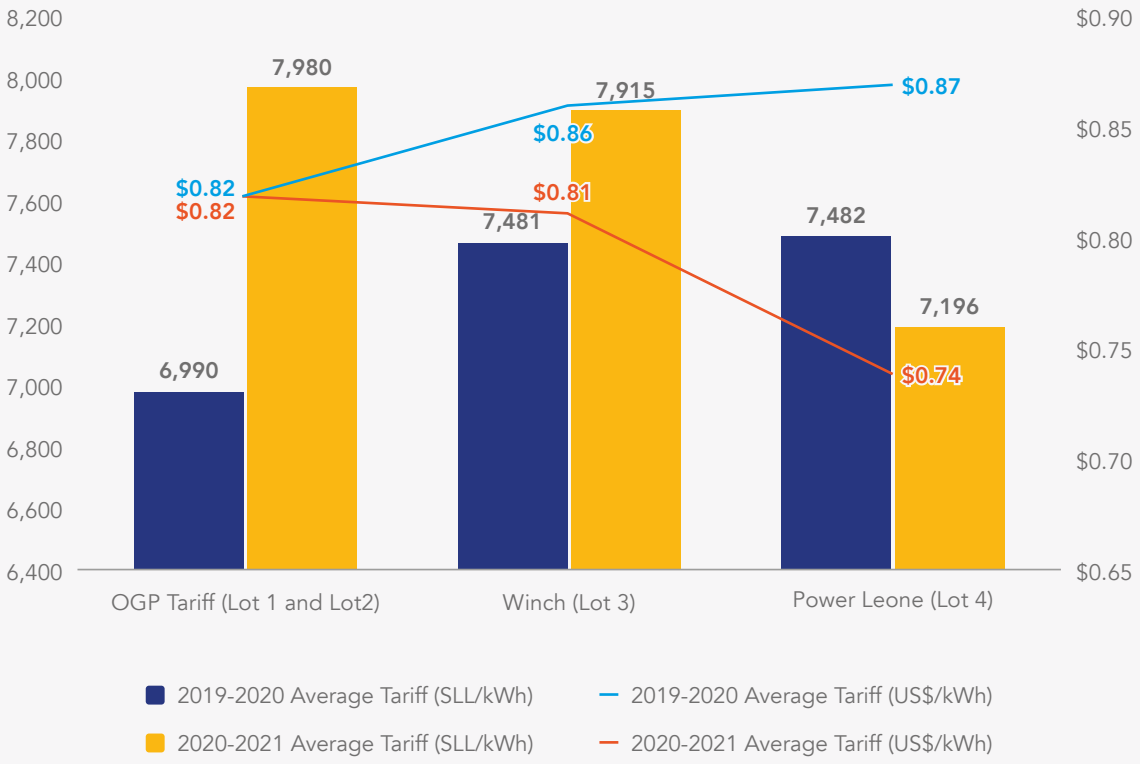
SLEWRC Approved mini-grid tariff structure in SLL and USD equivalent

DEVELOPER	2019-2020 TARIFF LEVEL		2020-2021 TARIFF LEVEL	
	Average Tariff (US$/kWh)	Average Tariff (SLL/kWh)	Average Tariff (US$/kWh)	Average Tariff (SLL/kWh)
1. OGP Tariff (Lot 1 and 2)	$0.82	6,990	$0.82	7,980
2. Winch (Lot 3)	$0.86	7,481	$0.81	7,915
3. Power Leone (Lot 4)	$0.87	7,482	$0.74	7,196

Source: SLEWRC Annual Report 2021.

FIGURE 3

Average Mini-Grid Tariffs in Sierra Leone (in SLL and USD equivalent)



Note: Although in US dollar terms the average tariff levels came down in 2020–2021 compared to 2019–2020 for one developer and remained the same for another developer, the tariffs went up in Sierra Leonean leones (SLL) because of the local currency's depreciation against the US dollar. End users pay their tariff in leones and its depreciation erodes any gains when they are required to absorb foreign exchange losses. In addition, there are bound to be differences and these differences are prevalent as the SLEWRC evaluates tariffs on a case-by-case basis considering prudency of costs that may be influenced by a myriad of factors including sizing, location, etc.

10.2 MINI-GRID TARIFFS IN NIGERIA

The Nigerian Electricity Regulatory Commission (NERC), in an interview for this research on 28 April 2022, indicated that some mini-grid tariffs are as low as **USD 0.30/kWh** while others are as high as **USD 0.80** to **USD 0.90/kWh**, but the average is within the range provided in the Rocky Mountain Institute (RMI) study of 2018 (see Table 3). Those that are as low as USD 0.30/kWh reflect the impact of the subsidy received while the high tariffs in the range of USD 0.80 to USD 0.90/kWh are largely those that did not directly receive subsidies as shown in the last column of Table 3.

The RMI study obtained tariffs directly from 10 mini-grid developers in Nigeria. These tariffs are shown in the first three columns in Table 3, while the last column shows the current range of tariffs along with some metrics obtained from the interview with the NERC in April 2022.

TABLE 3

Examples of Mini-Grid Tariffs in Nigeria

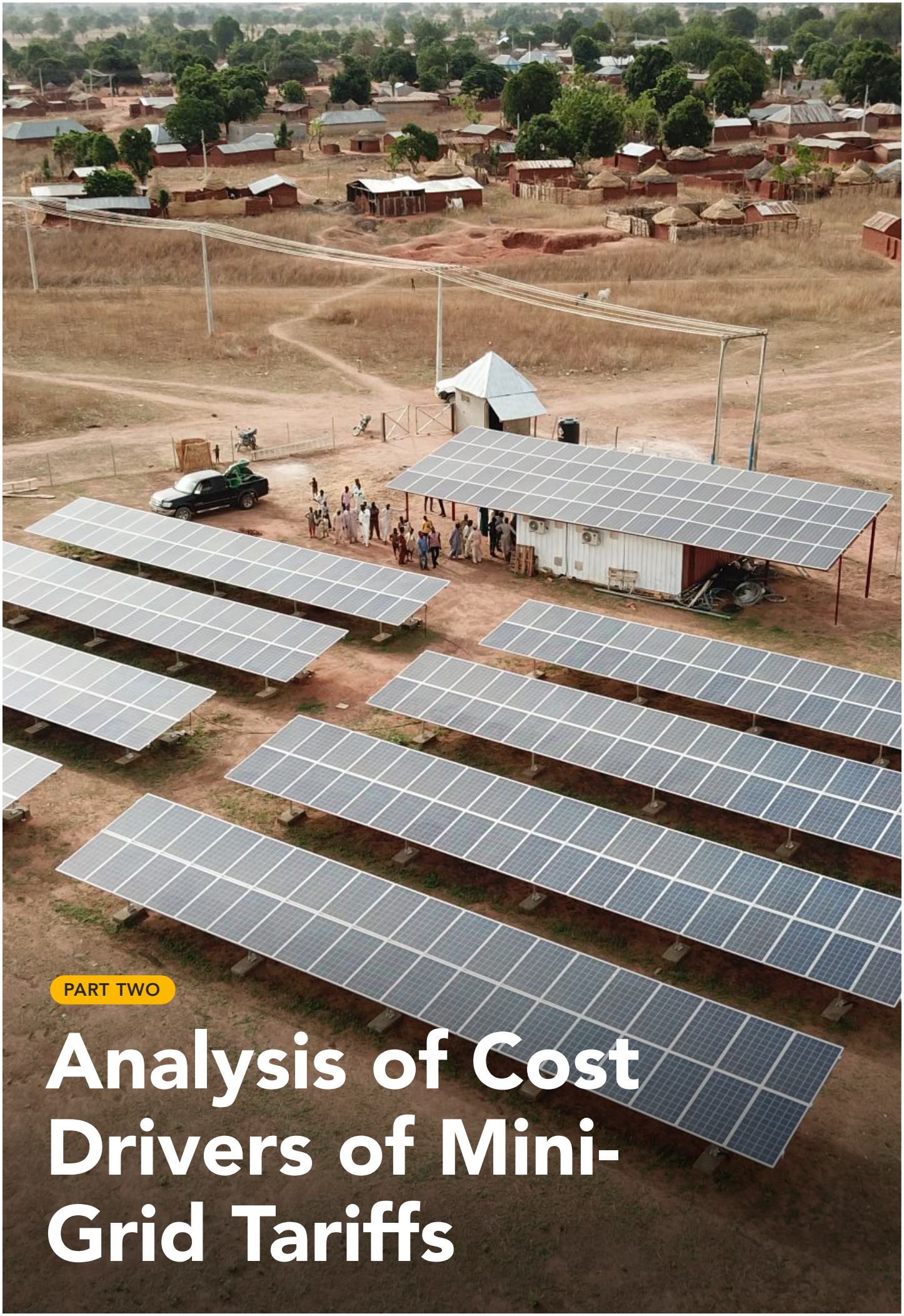
METRIC	RANGE	MEDIAN	CURRENT
–	RMI 2018 Study	–	NERC Interview of April 2022
TARIFF PER KWH	Naira120 – Naira300/kWh (US$0.34 - 0.86)	Naira200/kWh (US$0.57)	US$0.30 to US$0.80 & US$0.90
SYSTEM SIZE	16kWp – 100kWp	45kWp (RMI)	4kWp ->100kWp
CAPEX	Naira30-Naira30million	Naira50million ($140,000)	N/A
CAPEX PER CONNECTION	Not available (N/A)	N/A	N/A
OPEX PER ANNUM	Naira300,00-Naira2.4million ($900-$6,900)	Naira690,000 (US$2,000)	N/A
OPEX PER CUSTOMER PER MONTH	N/A	N/A	Naira 1,000 to Naira 2,000 US$2.25 - US$4.50
CAPACITY UTILIZATION	2% - 100%	19%	N/A

Source: Reliable and affordable electricity for Nigeria: Growing the mini-grids market, 2018, RMI, and STC interview of NERC staff on 28 April, 2022.

Note: The RMI concluded that: *"cost-reflective mini-grid tariffs are typically near N200/kWh (USD0.57/kWh), which is less expensive than the cost to run a small diesel or petrol generator set. A 0.75KVA Genset power costs USD0.86/kWh or Naira302/kWh"*[16].

Based on informal feedback from stakeholders, this research assessed whether the NERC has an "informal tariff cap". An "informal tariff cap" is a limit (a number or range) above which developers believe a regulator will not approve a tariff. Developers will therefore try to keep their tariffs application within that "informal cap", whether or not the tariff applied for is cost reflective. While it is difficult to definitively ascertain whether or not this is indeed the case, the NERC indicated that it does not have such a tariff cap. Developers apply for cost-reflective tariffs and the NERC will evaluate the tariff application, by checking for prudence of costs, among other considerations, as per the regulations.

[16] Reliable and affordable electricity for Nigeria: Growing the mini-grids market, 2018, RMI, and STC interview of NERC staff on 28 April, 2022



PART TWO

Analysis of Cost Drivers of Mini-Grid Tariffs

11 Service Territory Allocation

Across Sub-Saharan Africa, governments are using both unsolicited and/or solicited (competitive) approaches to allocate mini-grid service territories. There are both advantages and disadvantages of each of these approaches.

The upside of competitive bidding is that it often yields lower tariffs.[17] The competitive bidding process is attractive to private capital as it is deemed to partially de-risk the investment by its insulated contractual nature. In this competitive approach, if a bidder is allocated multiple sites, it can allow procurement at scale and therefore the developer may benefit from economies of scale for capital expenditure (Capex) costs. Increasing the scale of developers' portfolios can help to spread costs over more revenue generating customers, reducing the tariff that needs to be charged. It can drive down operational expenditure (Opex) too since staff can be employed at multiple sites in the same vicinity or at a central location for replacement spare parts. But the downside of this approach is that the bidding process is lengthy and may jeopardize implementation timelines. Setting up a bidding process tends to be slow and implementation can be uncertain if there are policy changes during the operation of the project. During the bidding a developer may bid unreasonably low tariffs to secure the project, and then either have to make an unreasonable tariff work by reducing the service level, or abandon the project, or ultimately ask for an increase in the tariff once they have secured the project and kicked off implementation.

The unsolicited (also referred to as the first-come, first-served) approach is deemed to be faster and does not have the risk of understating the true tariffs. A first-come, first-served approach is prevalent in countries that are trying to attract both foreign and domestic investment and where public procurement associated with a solicited (competitive) approach can sometimes be very slow to move because of its "hands-off nature". Indeed, a study conducted by USAID's Scaling Up Renewable Energy (SURE) programme on *Unlocking Africa's Mini-Grid Market*[18] found that: *"most countries in the nascent stages of mini-grid development accept unsolicited mini-grid projects to attract private investment in underserved areas"*. But the counter to this is that the developer, once they have secured the exclusivity of the service territory, might not be able to implement the project or might charge unreasonably high tariffs. This can however be mitigated through regulated time limitation provisions in the license for site reservation as

[17] Renewable Energy Auctions: Cases from Sub-Saharan Africa, IRENA, 2018; https://www.usaid.gov/energy/procurement/auctions.

[18] Unlocking Africa's Mini-Grid Market: Scaling Up Renewable Energy Program (SuRE), USAID, February 2021

well as other provisions to protect consumers from being taken advantage of by developers.

Sierra Leone does not seem to have used either of these approaches for service territory allocation; rather it employed a public-private partnership (PPP) model.[19] In this PPP model, the Rural Renewable Energy Project (RREP) Phase I was 100 percent grant funded whereas in Phase II, the RREP funded the mini-grid electricity distribution networks while competitively selected private funded and installed the mini-grid generation assets. The ownership of all assets acquired using RREP funds was transferred to the Ministry of Energy (MoE), which signed a usage rights, operation and maintenance agreement with the private sector operators for those government assets acquired under RREP. The relevant laws governing PPPs are applicable to this.[20] The private operators are responsible for the technical and commercial operation of the generation and distribution assets, as well as generating and selling electricity to the consumers for the duration of the license.

Nigeria, on the other hand, uses a combination of both the competitive (minimum subsidy tender (MST)) approach and unsolicited bids on a first-come, first-served basis.

Recommendation

Service territory allocation should be flexible to accommodate both approaches but, with clear criteria on when to use which approach. Whichever approach is taken, it must allocate a portfolio of sites to build economies of scale as well as include more sites that are commercially viable to mini-grid developers so that they can cross-subsidize between sites, otherwise governments may prioritize social objectives over the commercial sustainability of the mini-grid. With regard to the PPP model, there must be an upfront consensus between developers and the public sector around the level of tariff to be achieved and therefore the sustainable level of subsidy to be sought to avoid delays and uncertainties during and after project implementation.

[19] Mini grid tariffs between 2019 and 2020 were applied across the WP-1 sites which were mostly subsidized by the GoSL. WP-2 sites are implemented in a 'split assets' model where generation assets are procured by private partners while the distribution assets are subsidized by the GoSL. (SLEWRC Annual Report 2020

[20] http://www.ecreee.org/sites/default/files/Proposals/reoi-mini-grid_operation_in_sierra_leone_pppu.pdf

12 Capital Expenditure

Capital expenditure (Capex) costs are the biggest drivers of tariffs as they determine two elements of them. First, the investor has to recoup the initial capital expenditure (return **of** capital used in buying assets) and secondly, earn a profit or a return on the initial Capex (a return **on** capital used in buying assets). An accurate determination of initial Capex is therefore of greatest interest to developers, investors and regulators. Comparing Capex across different mini-grid markets and countries is difficult as project developers argue that projects are typically customized, administrative processes are lengthy and cumbersome, and engineers must often travel to remote sites for installations[21]. Further, Capex variations are driven by:

- Site selection, size and number of installations – average costs per kW installed decreases as developer portfolios increase. Economies of scale, investment and regulatory stability play major roles in final construction costs.
- Efficiencies over time in navigating regulatory compliance, procurement, and importation that drive down costs.
- Additional costs like logistics, site development, import duties, sales taxes that could attribute up to 40 percent of the final project Capex costs.
- Distribution costs.[22]

Regulators face uncertainty as to which components are driving overall mini-grid capital expenditure costs and are not able to compare the cost of mini-grid projects with absolute accuracy. This uncertainty is compounded by the fact that this is a nascent industry; there are no consistent cost benchmarks to use and data is scarce. Moreover, the myriad of donor support programmes means very few mini-grids have been developed without some kind of subsidy or grant support, making the real costs difficult to calculate.

Cognizant of the above limitations, regulators are building benchmarks over time from tariff applications. There is also indicative Capex per kW in various secondary data sources including the World Bank ESMAP 2022 Report[23] that provides mini-grid levelized cost of energy (LCOE) data from across the world. The Africa Minigrid Developers Association (AMDA) also publishes a benchmarking report based on data submitted by its mini-grid developer members. Both reports indicate that the

[21] Energy Sector Management Assistance Program, 2019, Mini-Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers. ESMAP Technical Report:014/19. World Bank, Washington, DC.

[22] Benchmarking Africa's Mini-Grids report, AMDA-ECA 2020.

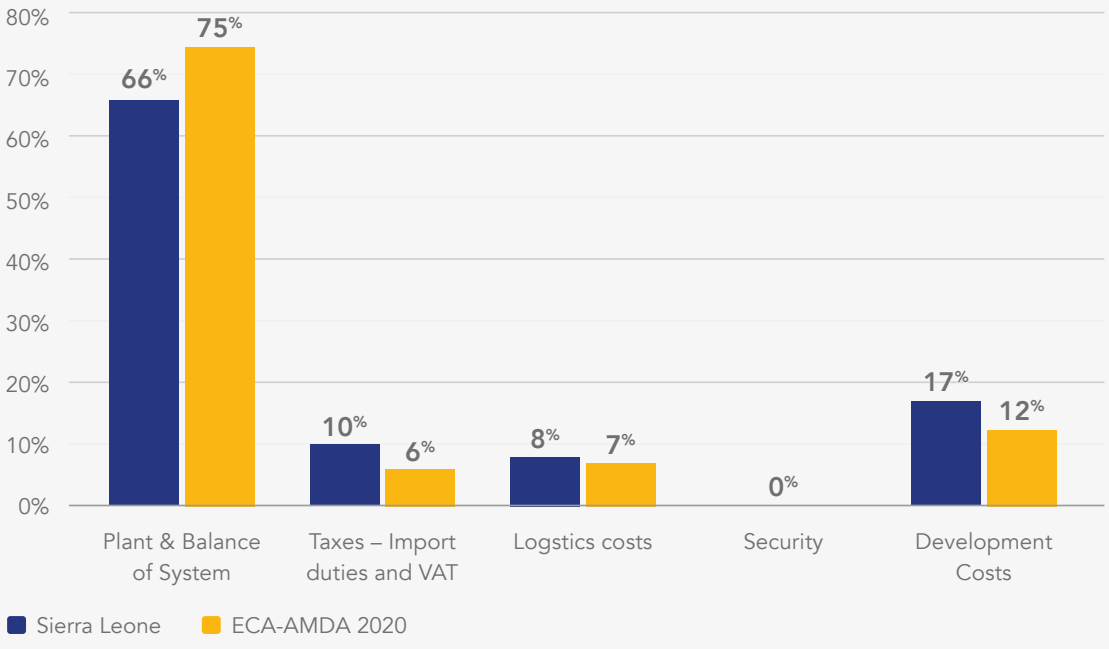
[23] Mini-Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers, 2022.

Capex varies widely from region to region. The World Bank ESMAP 2022 Report indicates that: *"downward trends in component costs mean that the up-front investment cost of solar and solar hybrid mini grids fell from about $8,000–$10,000/kW in 2010 to $3,900/kW in 2018 and less than 3,700/kW in 2021, …further expected to drop to $2,500/kW by 2030"*.

With regard to the composition of the Capex, SEforALL sought to analyze the Sierra Leone developers' Capex to derive the cost per kW to compare with the above World Bank benchmarks. However, developers in Sierra Leone calculate the cost per connection rather than the cost per kW. The Nigeria regulator also indicated that it has not calculated the Capex per kW. To fill this gap, the research analyzed Sierra Leonean developers' Capex breakdown in percentage points and compared it with the Capex percentage in the AMDA 2020 benchmark report. The following graph illustrates this percentage comparison:

FIGURE 4

Capital Expenditure Budget Lines



It is observed that plant and balance of system (generation assets, distribution assets, metering and connection assets) accounts for over 66 percent of the Capex amongst the Sierra Leone developers compared to 75 percent in the AMDA benchmark report. The World Bank ESMAP 2020 Report also indicates that components used for generating and distributing electricity account for 66 percent of total Capex costs. But these percentages do not provide the full picture.

The takeaway from both reports is that Capex costs for key equipment such as PV modules and batteries will continue to come down, and that larger portfolios and procurement of larger Capex assets will be needed for developers to benefit from economies of scale. Of interest for this study is to see the extent to which these cost savings can be passed on to the end user through lower tariffs, although depreciation of local currencies may erode these gains.

Import Duties: Import duties add to Capex costs. Sierra Leone's 'green lane' tax-exempt importation system for quality solar products aims to lower the import cost of mini-grid capital equipment, but developers often cite that these exemptions are unclear[24]. Sierra Leone Customs and Excise Tariffs are based on the Economic Community of West African States (ECOWAS) Harmonized Commodity Description and Coding System (HS). The applicable standard rate of import duty is 20 percent and the goods and services tax (GST) is 15 percent on imports for them to be eligible for the 'green lane' tax-exempt importation system[25]. But, according to GOGLA, Sierra Leone has a value-added tax (VAT) of 15 percent and an import duty of between 5 percent and 20 percent for solar products. There are exemptions for import duty and VAT but they are not universally applicable and are approved on a case-by-case basis"[26] This illustrates how import duties are unclear and application remains inconsistent, as is the case for many markets with VAT exemptions for solar products. The same challenge is reported in Nigeria, which offers tax exemptions on some "clean energy" equipment, i.e., while the customs code does not formally impose a customs duty or VAT, the Nigerian customs officials routinely levies a 5 percent VAT and 5 percent customs duty against PV modules[27].

The practice is that while tax exemptions are processed, imported equipment remains at the port incurring demurrage charges. In addition, one developer's feedback for this research stated that: *"the port is also highly cost inefficient [such]that [the cost of] getting a container inspected is relatively high compared to other markets."* The demurrage charges and delays in processing tax exemptions discourage developers from applying for tax exemptions, which adds to the Capex costs

[24] GMG MDP Document Series #10

[25] https://www.trade.gov/country-commercial-guides/sierra-leone-import-tariffs

[26] https://www.gogla.org/sites/default/files/resource_docs/sierra_leone_country_brief.pdf

[27] Bloomberg NEF

that are passed on to the end users in the form of higher tariffs.

Recommendation

In line with the World Bank Report projections above predicting decreasing capital costs, interventions should focus on bringing down Capex as this will have the greatest impact on lowering the tariffs. Regulators should develop original equipment manufacturer (OEM) benchmark costs against which to evaluate costs submitted by developers to evaluate whether or not they are reasonable. One approach that comes up is bulk procurement of capital equipment to drive down costs. Bulk procurement should go hand in hand with service territory allocation of large enough geographies to enable developers to reach the required economic size. These portfolio geographies should blend rural communities with commercially viable peri-urban and underserviced commercial areas to allow cross-subsidizations by mini-grids that makes them commercially viable. Bulk procurement modalities could learn from the Demand Aggregation for Renewable Technology (DART) programme funded by the Global Energy Alliance for People and Planet (GEAPP). The DART programme, launched in Nigeria by the GEAPP in 2021, combines demand pooling and aggregated purchasing of solar equipment, access to affordable finance, and coordinated logistics processes to unlock economies of scale for solar companies and achieve cost savings for end users[28].

Delays in processing tax exemptions cause developers to incur demurrage charges that can outweigh the amount of tax to be saved. In addition, the resulting delays in the customs clearance discourage developers from applying for the tax exemptions as it has a knock-on effect on the project implementation timelines. All of these add to the Capex costs that are passed on to the end users in the form of higher tariffs. These can be mitigated by accelerating the tax exemption clearance processing. Tax exemptions requirements and processing should be made clearer and more efficient for developers to realize the cost savings to be passed on to consumers through lower end-user tariffs. The Ministry of Finance can take action on this by issuing exemptions directly for new portfolio sites.

[28] https://www.rockefellerfoundation.org/news/new-10m-aggregated-solar-equipment-procurement-financing-facility-launches-in-nigeria/

13 Capacity Factor (Load Factor) and System Utilization

The capacity or load factor and system utilization, including unutilized capacity, are both related to capital expenditure (Capex).

13.1 CAPACITY FACTOR (LOAD FACTOR)

The capacity factor is the actual total energy generated measured in a given time period (e.g., one year) as a percentage of the maximum amount the same generation plant would have generated at uninterrupted full capacity over the same period.

A low-capacity factor reflects low total energy being produced for the same (fixed) Capex investment. Low-capacity factor leads to a higher tariff as a high Capex cost is spread over a low energy unit output. Table 4, an extract from the World Bank ESMAP 2020 Report illustrates this point:

TABLE 4

Levelized Cost of Energy by Capacity Factor, 2018, 2021, and 2030

CAPACITY FACTOR (%)	LEVELIZED COST OF ENERGY (US$/kWh) 2018	2021	2030
22	0.55	0.38	0.29
40	0.42	0.28	0.20

Note: The 2018 LCOE data are for a best-in-class 294-kW solar hybrid mini-grid in Bangladesh serving more than 1,000 customers (more than 5,000 people). LCOE data for 2021 are based on a representative mini-grid synthesized from average cost and consumption levels in three mini-grids in Ethiopia, Myanmar and Nigeria and commissioned in 2020 or 2021. The 2030 LCOE is for a best-in-class mini-grid based on projected component costs in 2030. (World Bank ESMAP, 2020.)

It can be noted that the higher the capacity factor, the lower the tariff. It should also be noted that the 2021 example above includes Nigeria and the tariffs there are consistent with the response given by the Nigerian Electricity Regulatory Commission (NERC) during the interview for this report.

This research examined the tariff model used in Sierra Leone and found that it does not provide for the user to input the capacity factor to derive the energy generated. Therefore, it could not be established what capacity factors the developers are using in their tariff modelling and if that is being disclosed to the regulator. Table 5 provides an example extracted from another African regulator on how the capacity factor is shown and used:

TABLE 5

Project Capacity Factor in Tariff Modelling

	INPUT 1	INPUT 2	UNITS
INSTALLED (NAME PLATE) CAPACITY	100	100	kW
CAPACITY FACTOR	15.0%	20.0%	%
POWER GENERATED	**15.00**	**20.00**	kW
AVAILABILITY	95.0%	95.0%	%
EXPECTED POWER DISPATCH	**14.25**	**19.00**	kW
TECHNICAL (GRID) LOSSES	4%	4%	%
NET POWER AFTER TECHNICAL LOSSES	**13.68**	**18.24**	kW
ANNUAL HOURS OF ENERGY DELIVERY	8,760	8,760	hrs
ENERGY DELIVERED ANNUALLY	**119,836**	**159,782**	kWh
PLANT ANNUAL DEGRADATION RATE	0.50%	0.50%	%
PLANT ECONOMIC USEFUL LIFE	25	25	Years

Table 5 illustrates how tariff capacity factor is built into the tariff model and how the use of two different capacity factors (15 percent vs 20 percent) changes the energy delivered. This ultimately impacts the tariff charge.

12.3 SYSTEM UTILIZATION (AND IDLE CAPACITY)

In addition to the capacity factor, once the system is optimized to produce at its full capacity, the power generated must be sold. Otherwise, it means the system is oversized and has unutilized capacity. One of the regulatory principles requires that an

asset must be "used and useful" for it to be considered in tariff setting. That means that any unutilized capacity must be excluded from the tariffs paid by current customers. This research therefore sought to establish whether any unutilized capacity is excluded from tariffs, by examining the tariff model in Sierra Leone and Nigeria, analyzing responses from developers, and conducting interviews with the regulators.

Some developers design and build their systems based on future projected demand rather than current actual demand. This leads to unutilized capacity in the early years but developers can utilize this extra capacity as demand ramps up over the years to design capacity. They do so to take advantage of economies of scale. Other developers will design and build their systems sized to the current demand projections with some reserve margin to deal with peak loads. Developers in Sierra Leone indicated that the mini-grid tariff is a cost plus, including the unutilized capacity, which is necessary to ensure the grids can meet growing demand in the initial years of operation. Developers further argued that systems could be sized without unutilized capacity from the outset, but then the backup generator would run more frequently as demand increases, which would end up increasing the tariff. Effectively that means that the market risk (demand risk) is fully allocated to the consumer. Analysis of tariff models (similar in both Sierra Leone and Nigeria), confirms that the models are designed to charge the unutilized capacity to the current customer.

In interviews, the Sierra Leone Electricity and Water Regulatory Commission (SLEWRC), in response to a questionnaire for the African Forum for Utility Regulators (AFUR)[29] indicated that the calculation tool only considers demand and does not take into account idle capacity, i.e., idle capacity is charged to current customers.

The 2021 SEforALL report also identified that: "an important takeaway from the mini-grid site selection process in Sierra Leone is that less emphasis was placed on demand-side considerations during initial (WP-1) site selection, which prioritized supplying electricity to the CHCs… While the provision of electricity to critical social services is important, strategies to mitigate high tariffs may be needed if these sites have low demand… In contrast, WP-2 focused more on PUE opportunities, with several studies commissioned by UNOPS to support the three developers in this regard."[30] This could imply some unutilized capacity for WP-1 assets if they were oversized relative to actual demand requirements.

The Nigeria Rocky Mountain Institute (RMI) study (referenced earlier) showed that the capacity utilization was in the range of 2 percent

[29] Mainstreaming mini-grid tariff settlement tools and methodologies across Sub-Saharan Africa Regulators: Countries' Tariff Tools Review: AFUR interview of SLEWRC Tariff Analyst of 22 June 2021

[30] Increasing Energy Access in Sierra Leone: Mini-grid survey analysis on tariffs, subsidies and productive use, March 2021.

– 100 percent, with a median of 19 percent for the mini-grids in the study (see Table 3 on tariffs in Nigeria). The NERC reiterated that although the tariff model is built to charge the unutilized capacity to current customers, it does not consider design capacity or capacity factors. Instead, it looks at the tariff model to estimate the optimal power supply and modify to remove any excess capacity because if there are only a few subscribers for an oversized system the tariff will be too high. In addition to the NERC review, the Rural Electrification Agency (REA) also checks to ensure there is no oversizing before awarding a subsidy.

Recommendation

Developers should show the capacity factors as well as the unutilized capacity of their systems in their tariff applications. Regulators should enforce the adoption of the capacity factors for each generation technology that is in the least cost power development plan (LCPDP) to obtain the most efficiencies in mini-grid power generation. The market risk (demand risk) should not be borne by the consumer. The unutilized capacity should be excluded from the mini-grid tariffs. Calculating a tariff inclusive of unutilized capacity of 50 percent is enough to undo the effects of a 50 percent Capex subsidy. This research was not able to establish the current unutilized capacity of every developer in Sierra Leone, but is of the view that it is most likely the biggest contributor to neutralizing the impact of the subsidies and therefore the main factor behind the relatively high tariffs in the country. This view is informed by the fact that the SLEWRC does not make adjustments for unutilized capacity in the same way as the NERC. As noted above, the SEforALL 2021 report also identified that in Rural Renewable Energy Project (RREP) work package 1 (WP-1) more emphasis was placed on the supply of electricity to community health centres (in the wake of the Ebola outbreak) than on demand, while noting that strategies to mitigate high tariffs could be needed if these sites had low demand. However, the feedback provided for this research by developers indicated that they don't have idle capacity, but they have misallocated capacity, i.e., excess solar at many sites (or too little daytime demand) and too few batteries (in too bad a condition on WP-1).

Developers should use modular designs to mitigate the risk of oversizing. It is better to start with capacity that does not exceed the immediate demand and increase the size of the mini-grid as demand increases. This will lower the initial investment deployed. The same should be the case for the distribution system; it takes longer for people to connect, and hence there is a need to start by building the distribution network where there is an immediate demand for connection. But the developers are not sure if funders will agree to the resulting loss of economies of scale. On the other hand, there is no cost benefit analysis that has been done to show that the benefits of unutilized capacity outweigh the loss of the economies of scale foregone, especially in light of declining equipment costs. This is an area for further research that may help the mini-grid industry more effectively understand and mitigate this trade-off.

Another proposal to decrease capital

expenditure (Capex) related to tariff is premised on the fact that the most expensive part of the Capex is the battery bank; a developer should therefore avoid oversizing the batteries. This can be achieved through demand side management by implementing measures such as time-of-use (ToU) tariffs or automatically disconnecting loads.

Finally, developers are of the view that if sites are rightsized, there is a risk that, as demand grows, the systems will quickly become undersized resulting in outages until they can be expanded. The right sizing policy prescription therefore does have downsides and the government needs to be aware of that. However, this research deems that this a risk that can be mitigated through good demand forecasting and advance system expansion planning.

Some of this unutilized capacity can be absorbed through demand stimulation programmes supported by development partners. Indeed, as noted earlier, work package 2 (WP-2) supports developers on the demand side for productive uses of energy (PUE), opportunities to grow demand, improve system utilization, lower tariffs and increase business viability.

14 Depreciation

14.1 SHORTER LICENSE PERIOD IMPACTS DEPRECIATION: STRAIGHT-LINE METHOD EXAMPLE

For existing mini-grid assets, the depreciation period used by developers is the shorter of either the license period or the economic useful life of the asset. The reason for this is that the investor wants to recover their investment within the license period. In Sierra Leone, the license period of mini-grids is 20 years, and therefore even if a mini-grid asset has an economic useful life of more than 20 years, the investor will compress the regulatory depreciation to within 20 years. In Nigeria the license period of mini-grid assets is 25 years. On the other hand, typically the state utilities operating the grid assets are given a license period of 40 years. Using a straight-line method (because of its simplicity), Table 6 helps to illustrate the impact of licensing for 20 years versus 25 years on the depreciation charged to the tariffs using a fictional asset costing USD 100:

TABLE 6

Impact of Short License Period/Compressed Depreciation Period on Tariff

	STRAIGHT-LINE DEPRECIATION PERIOD = LICENCE PERIOD 20 YEARS	STRAIGHT-LINE DEPRECIATION PERIOD = LICENCE PERIOD 25 YEARS
ASSET COST	$100	$100
DEPRECIATION YEARS	20	25
DEPRECIATION CHARGE PER YEAR	5	4
kWh UNITS DISPATCHED PER YEAR	5	5
DEPRECIATION COST/kWh IN TARIFF	$1	$0.80

Table 6 illustrates that the license period matters. The shorter license adds 20 percent more depreciation to the tariff compared to a longer license period.

In Sierra Leone the private-public partnership (PPP) agreement is for 20 years, so any increase in the license period should be done in tandem with the PPP agreement.

14.2 IMPACT OF DEPRECIATION ON TARIFFS IN SIERRA LEONE VS THOSE IN NIGERIA – ANNUITY METHOD

Both Nigeria and Sierra Leone use the annuity method of depreciation, although the straight-line method is the most used method of depreciation amongst regulators. Over the lifetime of the

assets, the annuity method gives a higher total depreciation charge than the straight-line method. But the former backloads the depreciation amount while the latter charges a constant amount throughout the lifetime of the asset. The annuity method is therefore supposed to support lower tariffs in earlier years, but we are not seeing that come through in tariffs in Sierra Leone. Since both Sierra Leone and Nigeria use the same depreciation method, there should be no difference caused by the depreciation methodology on the tariffs. The difference is caused by the shorter depreciation period caused by a shortened licensing period as explained above.

Recommendation

As illustrated above, longer license periods translate to longer payback periods, e.g., 25 to 40 years (similar to state utilities), will reduce tariffs, but will not affect returns on investments. The Ministry of Energy (MoE) as the policymaker should amend the mini-grid licensing period from 20 years to at least 25 years. Developers would then use a depreciation period of at least 25 years instead of 20 years for those assets that have such long lives. The five-year extension would need to happen immediately for it to have an immediate impact on tariffs.

Alternatively, where practical, the regulator in Sierra Leone should recommend to the developers that they use a depreciation period of at least 25 years. The difference of five years should be recognized as residual value that can be compensated immediately through a smart subsidy or the regulator can extend the license for a further five years when the current license lapses in 20 years' time. If compensated immediately by smart subsidy, the proviso is for the assets to pass over to the community with the developer on an operating and maintenance (O&M) contract.

The PPP agreement between the Government of Sierra Leone (GoSL) and the mini-grid operators is currently for a period of 20 years. Increasing the license period should be in tandem with increasing the PPP agreement period.

15 Ability and Willingness to Pay

Before implementation, each developer conducts an ability and willingness-to-pay study. It is not clear if the avoided cost is considered in this analysis, as this is also not provided for anywhere in the tariff tool. This may explain why customers find that electricity is costing them more than the alternatives (avoided cost) they had before. The regulator attributed this partially to the consumers buying energy-inefficient appliances and is addressing this issue by conducting consumer education encouraging consumers to buy energy-efficient appliances. This research study was not able to establish whether energy efficiency was the cause of higher costs. The research is of the view that in addition to the energy efficiency that the regulator is addressing, it should support consumers to understand what constitutes the alternatives for purposes of measuring avoided costs used in the ability and willingness-to-pay study. This will ensure that there is no confusion on "ability and willingness" concepts that may lead to wrong assumptions/conclusions about what customers demand and what they can afford.

Recommendation

The regulator should calculate reasonable mini-grid tariff levels by making a comparison with accurate avoided cost.[31] In so doing tariff rates are set to reflect what consumers have otherwise been spending on pre-existing power sources such that mini-grid tariffs are lower than those avoided costs for it to make economic sense when switching. Developers and regulator community engagements should therefore assist communities by providing accurate information for avoided costs assessments. This will address the current situation where consumers are abandoning the mini-grid citing unaffordability compared to alternatives.

Pro-private sector regulation should be counterbalanced by a proviso that gives the regulator recourse in the event of proven evidence of uncompetitive pricing by a developer. Communities should be empowered, through community engagements, to negotiate with developers from a position of knowledge.

[31] Care should be taken not to reference the avoided costs to the main grid tariffs.

16 Weighted Average Cost of Capital

Weighted average cost of capital (WACC) is the target rate of return provided to mini-grid investors. Each developer gets a different rate of return from the Sierra Leone Electricity and Water Regulations Commission (SLEWRC). Mini-grid developers in Sierra Leone indicated having been granted a WACC range of between 10 percent and 17 percent. The WACC is entered as one value in the tariff, so there is no provision for cost of debt, cost of equity or capital structure. This WACC will have different levels of return on equity depending on the capital structure and cost of debt (interest rate). Mini-grids are not able to attract debt funding so most of their funding is equity and grants. Since the sector is relatively nascent, the expected returns on equity are higher than a typical utility investment. The cost of debt funding is tax deductible, which lowers the WACC when debt is included in it. However, too much debt also increases the risk of distress and therefore there is a limit on how much debt there can be in the capital structure.

By comparison, in Nigeria, the return on investment is also prescribed in the regulations as a WACC. The cost of the debt is explained as the "expected" debt interest rate; the cost of equity applicable for registered projects is prescribed as expected debt interest rate + 6 percent. Unregistered projects (above 100kWp) are not bound by cost of equity of expected debt interest rate +6 percent, but the regulator has tended to use this as guidance for unregistered projects. As in Sierra Leone, the projects are not able to access debt so they are predominantly funded by equity and grants and the expected return on equity (ROE) is higher than normal utility investments. In the interview for this research, the Nigerian Electricity Regulatory Commission (NERC) indicated that the ROE depends on the amount of grants in the capital mix; it can be up to 25 percent for projects that have some grant funding. For mini-grids that are fully equity funded the ROE can be up to 35 percent.

TABLE 7

Comparison of WACC in Sierra Leone and Nigeria

	SIERRA LEONE	NIGERIA
COST OF EQUITY (ROE) – WITH GRANT	Not available (N/A)	≤ 25% (pre-tax)
COST OF EQUITY (ROE) – WITHOUT GRANT	N/A	≤ 35% (pre-tax)
WACC RANGE – WITH GRANT	**10% – 17%**	**≤ 18% (post-tax)**
WACC RANGE – WITHOUT GRANT	N/A	≤ 25% (post-tax)

Note: 30% corporate tax

Table 7 shows that developers in Sierra Leone receive a lower return on equity than their counterparts in Nigeria. Therefore, this research did not establish that WACC, on its own, is one of the causal factors for the tariff difference between Sierra Leone and Nigeria.

17 Operating and Maintenance Cost

Operating and maintenance (O&M) costs per customer per year for three Sierra Leone operators range between USD 47 and USD 51 with an average around USD 48. In Nigeria they range between USD 27 and USD 54 per year with an average of USD 41 The biggest component is the plant operating costs followed by salaries. The Nigerian Electricity Regulatory Commission (NERC) did not provide a breakdown of the individual O&M costs by line items but explained the lower costs saying that only four to five of the mini-grids are internationally owned while most others are locally owned. Those that are internationally owned have higher management costs due to the costs associated with expatriates. Operators in Sierra Leone said another likely factor contributing to the difference in cost compared to Nigeria is the small size of individual sites in Sierra Leone. Table 8 illustrates the average O&M costs in the two countries.

The average operating expenditure (Opex) costs in Sierra Leone and Nigeria are lower than those seen in the World Bank EMSAP 2020 Report that indicates that: *"mini grid operating expenditure (Opex) averages around $80 per customer per year…staff costs on average account for 76 percent of operations costs…new remote-controlled, prepay smart meters and remote-monitoring technologies have slashed labor costs per mini grid…costs are expected to decline because of technological advances."*[32]

TABLE 8

Average OPEX in Sierra Leone Compared to Nigeria

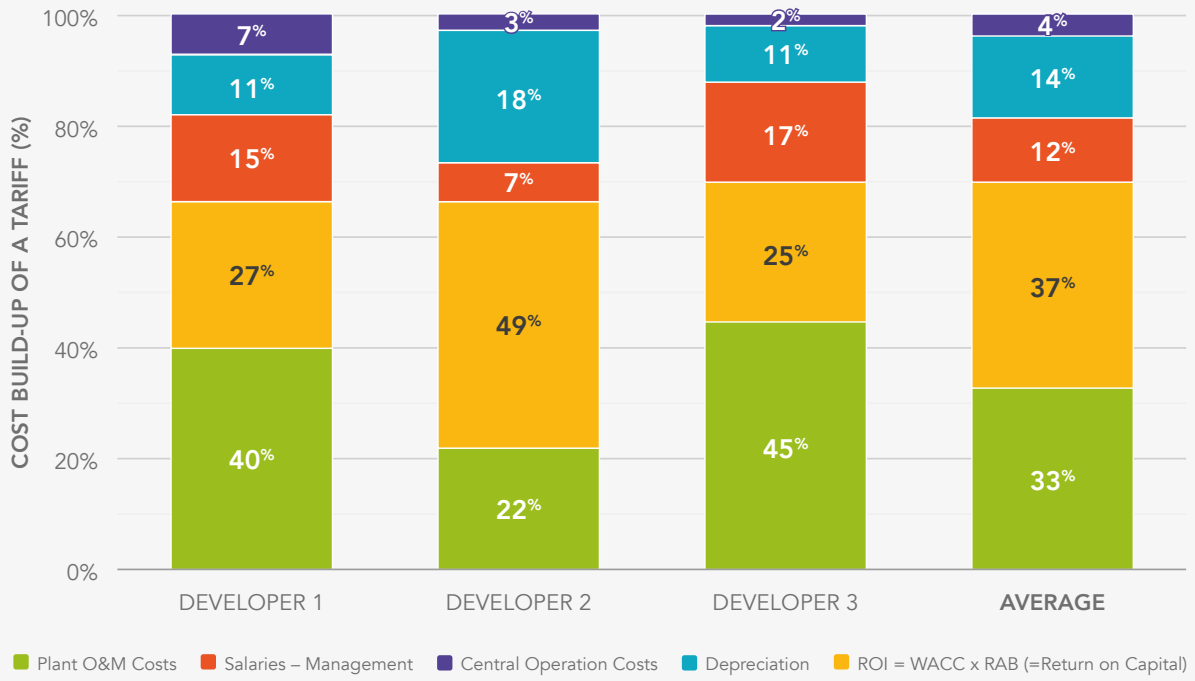
	DEVELOPER A	DEVELOPER B	DEVELOPER C	SL $ AVERAGE	NIGERIA
PLANT O&M COSTS	$33	$32	$33	$33	
SALARIES	$12	$11	$12	$12	
CENTRAL OPERATION COSTS	$6	$4	$1	$4	
TOTAL OPEX ANNUALLY	**$51**	**$47**	**$47**	**$48**	**$27 to $54**

Figure 5 shows the cost buildup of mini-grid tariffs for individual developers and an average for the three developers in Sierra Leone. There are five cost elements that make up a tariff.

[32] ESMAP, World Bank Group, Mini Grids for Half a Billion People, Market Outlook and Handbook for Decision Makers, 2020

FIGURE 5

Elements of a Mini-Grid Tariff including Average Elements



On average the leading drivers of mini-grid end-user tariffs in Sierra Leone are the return on investment (due to the high capital expenditure to which the weighted average cost of capital WACC ranging from 10 percent to 17 percent is applied) followed by plant operating and maintenance costs, and depreciation. Management salaries are fourth and the last element is central operation costs.

The observation from Figure 5 is that the Opex differential between Sierra Leone (ranging between USD 47 and USD 51) and Nigeria (ranging between USD 27 and USD 54) could be a marginal contributory factor to the tariff differential, but not a significant one.

Recommendation

The regulator should make use of cost benchmarking for testing prudency of operating costs in tariffs applications. Over the long term, developers should build capacity to use more local labour resources for plant O&M and thus reduce labour costs.

Mini-grids should continue to improve operational performance and efficiency to reduce operating costs. Localization combined with the adoption of plant O&M cost-saving technology, such as remote monitoring, as well as demand-side management to increase the lifetime of batteries by offering incentives to consume energy during daytime, should be encouraged as appropriate to the project operating circumstances.

18 Subsidies

The subsidies under the Rural Renewable Energy Project (RREP) in work packages 1, 2 and 7 (WP-1, WP-2, and WP-7) can be summarized as follows:

TABLE 9

Subsidies from RREP to the Developers

WP-1	WP-2	WP-3
Expanded (from 6.6kW to 36kWp) 50 of the previously constructed health centre solar power stations and installed distribution networks throughout each village, creating independent mini-grids. These distribution networks would extend electricity access to houses, schools and businesses in the various villages. **"Mini grid tariffs in the Year 2019-20 were applied across the WP-1 sites which were mostly subsidized by the GoSL"**[33]	A further 44 (36kWp) mini-grid installations through co-investment by RREP with the private sector operators **"WP-2 sites are implemented in a 'split assets' model where Generation Assets are procured by Private Partners while the Distribution Assets are subsidized by the GoSL"**[34]	Tariff subsidy for non-generation assets and elimination of public reserve account payments. **Through this work package approved in 2020, additional funds will be used to procure non-generation assets (electricity meters and indoor connection materials, e.g., sockets), and to eliminate public reserve account payments by the operators for the first four years of the project**[35].
Three private sector companies (Winch Energy, Off-Grid Power/PowerGen, and Energicity/Power Leone) signed a PPP agreement with the GoSL, leveraging more than GBP 10.8M of financing from private sector investment, to maintain and operate the 95 mini-grid systems, allocated to them in lots respectively[36].		

Source: http://www.energy.gov.sl/home/rural-renewable-energy-project/; http://www.energy.gov.sl/wp-content/uploads/2021/07/Fact-sheet_RREP-Updated-June-2021-3.pdf

The three developers in the research study reported having received various subsidies. These are summarized in Table 10. The subsidies were intended to lower tariffs, increase affordability, increase access and support the viability of the mini-grid business.

[33] Source: SLEWRC Annual Report 2020 Page 26

[34] Source: SLEWRC Annual Report 2020 Page 26

[35] 10,000 people connected through the Rural Renewable Energy Project, GoSL, UNOPS, FCDO, June 2021-3, Page 2

[36] 10,000 people connected through the Rural Renewable Energy Project, GoSL, UNOPS, FCDO, June 2021-3, Page 2

TABLE 10

Subsidies Received by Developers

SUBSIDY TYPE	DEVELOPER 1	DEVELOPER 2	DEVELOPER 3**
Asset split/RREP in form of assets	Yes*	Yes*	Yes*
Connection subsidy per customer	None reported	$265.99	$450 – $600
UEF per connection	None reported	None reported	$592

* The subsidies were in-kind and delivered to the project by UNOPS that built distribution grids with FCDO funding.

**Subsidies received as a percentage of total costs range between 35% and 50%.

The subsidies may be incorporated into the tariffs as follows:

1. Asset split (subsidies in kind of distribution grid assets with FCDO funding)

The developers reported having received subsidies in kind in the form of distribution grid assets from the UN Office for Project Services (UNOPS) with Foreign, Commonwealth and Development (FCDO) funding. The developers have excluded distributions assets from the regulatory asset base in the tariff model as well as the costs related thereto. This is the correct approach that is used in regulatory practice.

The impact of this exclusion is to lower the depreciation charge and the return on investment resulting in lower end-user tariffs. The quantum of the impact on the tariff per kWh depends on the value of the distribution asset and the number of connections benefitting from that distribution grid. The costs of the distribution were paid by UNOPS and hence impact is not quantifiable from the developers' data. As noted above, this is to be discussed with the parties involved, on consensus reached between the RREP, UNOPS, developers and the Government of Sierra Leone on target tariff and quantum of subsidy per kWh from this subsidy.

2. Other Capital Subsidies (Connection Subsidies received)

Connection subsidies are treated as a capital grant. Capital grant-funded assets are also excluded from the regulatory asset base that is used in the calculation of the depreciation and return on investment that is added to the tariff. The tariff model has a provision in the inputs assets tab to enable the user to enter the percentage of financing from non-grant funding. This effectively subtracts the grant-funded portion of the total assets, with the impact of reducing the end-user tariff. However, a performance-related profit margin is provided for in the model as an incentive to developers for maintenance of these grant-funded assets. Two developers reported receiving connection subsidies. Developer 2 treats the connection subsidy as explained above. Further discussion will be held with developer 3 to re-confirm that they have also

treated the connection subsidy the same way.

3. Universal Energy Facility

The Universal Energy Facility (UEF) is a results-based financing (RBF) programme. The grant is USD 592 per connection and is paid to the developer upon verification by the UEF programme manager of actual connections. One developer confirmed receiving the UEF subsidy. Another developer confirmed having applied for the grant. Ideally, a developer should not include the costs that they will recoup from RBF in a tariff. However, they face the risk that the RBF subsidies may not be disbursed.[37] Therefore, they can delay deduction of this subsidy from their actual costs until the RBF subsidy is received. However, some regulators may require the developers to deduct the RBF subsidy upfront where it is highly probable that they will receive it. In the case of Sierra Leone, the Sierra Leone Electricity and Water Regulatory Commission (SLEWRC) will need to check that the developer deducts the UEF grant from the related costs to lower the end-user tariffs.

4. Subsidies as a percentage of total project Capex

One developer in Sierra Leone estimates to have received a subsidy in the range of 30 to 50 percent of total capital expenditure (Capex). But, as already stated, it is yet to be established whether there was a general practice of an upfront consensus on the target tariffs to be achieved for subsidies awarded to developers.

The 2021 study by Sustainable Energy for All (SEforALL) also reiterates that: *"in the case of Nigeria, there is a direct correlation between the level of subsidy and tariffs. A comparison of the Rural Electrification Fund (REF), Nigeria Electrification Project Performance-Based Grant (NEP PBG), and Nigerian Energy Support (NESP) programmes shows that REF subsidies cover 50-70 percent of Capex while the NEP PBG covers only about 30 percent of the Capex. As a result, tariffs for NEP sites (at USD0.39-0.79/kwh, with average of average of USD0.58/kWh) are between 25 percent and 108 percent higher than REF tariffs (at USD0.32-0.39/kwh). It is worth noting that there are other factors that influence tariffs, including location, presence of productive uses, cost of financing, site accessibility etc."*[38]

Subsidies have the impact of lowering end-user tariffs, but this research observes that relying on subsidies alone to bring down tariffs is not sustainable. Drawing on Uganda[39] as an example where developers used a private-public partnership (PPP) model like Sierra Leone, the subsidy was initially at 60 to 70 percent of total Capex. Using competitive bidding, the tariff came in at USD 0.50, but the Ugandan government wanted a tariff of USD

[37] Increasing Energy Access in Sierra Leone, SEforALL.

[38] Increasing Energy Access in Sierra Leone: Mini-grid survey analysis on tariffs, subsidies and productive use, March 2021.

[39] Uganda: A Bundled Approach to Mini-Grid Tendering, Get.Transform.

0.30 which then required a higher subsidy of 80 percent of total Capex. This USD 0.30 tariff cap caused delays, although on the positive side, it was clear for developers early enough what the target tariff was. As this Uganda example illustrates, the lower the tariff, the higher the subsidy.

5. Revenue subsidies

The developers did not report receiving any revenue subsidies and an examination of the respective tariff application models submitted by developers to SLEWRC did not find any revenue subsidies.

6. Cross Boundary Tariff Buy-Down Pilot

The Sierra Leone tariff buy-down pilot is in the early stages of design so the exact details and expected impact on the tariffs can best be articulated by Cross Boundary along with the participating developer. But based on the model first implemented in Tanzania: *"the pilot will provide a subsidy, for a determinate period (e.g., five years) that allows developers to reduce tariffs charged to customers, but not have a negative impact on project returns. Cross Boundary will work with each developer to determine the lowest average tariff the developer could charge customers for at least 20 years which ensures the projected revenues, including subsidy payments, are sufficient to cover Opex, depreciation, and project return in the long term. The expectation is that, after pilot period, the developers continue to charge customers the lower tariff, and no longer receive a subsidy. The hypothesis of the pilot is the lower tariff causes an increase in energy consumption. The expected revenue increases from higher consumption, will cover any additional capex or expansion necessary. The mini-grid can therefore run profitably after the subsidy expires at a tariff that only covers Opex, thus preserving initial project net present value (NPV)."*[40]

The Nigerian regulator on its part indicated that availability of grants directly reduces the tariff. Some subsidies can be up to 99 percent of Capex. The grant subsidies should be properly applied to achieve the desired impact of reducing the tariff. Because of these subsidies, some mini-grid tariffs in Nigeria are as low as below USD 0.30. Those without grant subsidies are as high as USD 0.80 to USD 0.90, but the average is within the range provided in the 2018 Rocky Mountain Institute (RMI) study (referenced earlier in this report). Those that are as low as USD 0.30 reflect the impact of the grant received while the high tariffs, in the range of USD 0.80 to USD 0.90 indicate those developers did not receive grants. The connection subsidy per customer ranges between USD 350 and USD 600. Nigeria also has an RBF subsidy programme as well as the minimum subsidy tender (MST).

The question that this research sets out to address is whether these subsidies achieved the desired impact of reducing the tariff

[40] Innovation Insight: Measuring the impact of reducing mini grid tariffs on customer consumption and grid NPV, Energy4Impact.

sufficiently. As explained in the earlier sections of this report, there are a number of possible causes why the subsidies have not been as effective in reducing the tariffs in Sierra Leone as they were in Nigeria.

While this research identified one of the drivers of higher tariffs to be the unutilized capacity (market risk) that has been transferred to the customers, the developers alluded to many others. These include: low daytime demand; a much lower level of subsidy relative to the cost per connection; Sierra Leone's rural mini-grids that in many instances lose money or just break-even; mini-grid operators funding replacements through escrow accounts that makes the subsidy in Sierra Leone much less significant; a negative subsidy of free power to clinics that has real costs; negative subsidy of operating losses making sites picked for social imperatives; and drawn-out execution by UNOPS (contract has been extended again to rectify medium voltage grid sites) leading to very high development costs.

Recommendation

The drive for lower tariffs should not just be about providing subsidies to the developers, as this is often a short-term solution. There should be convergence upfront between stakeholders on a mini-grid tariff that is affordable to the community and acceptable to both the private and public sectors. The difference between the mini-grid tariff and the cost-reflective tariff is covered by a sustainable smart subsidy. Developers' feedback for this research indicates that tariffs of USD 0.30–USD 0.45/kWh in rural sites will require nearly 100 percent Capex subsidy, but it is not clear whether this tariff range factors in the forecast Capex cost reduction discussed earlier in this report. That level of subsidy can be optimized through a portfolio approach of sites combining commercially viable peri-urban areas or underserved areas with rural villages.

19 Multi-Year Tariff Order Tariff Tool in Sierra Leone

The multi-year tariff order MYTO tariff tool was introduced in Sierra Leone in June 2021. Before this, the Sierra Leone Electricity and Water Regulatory Commission (SLEWRC) was using an annual tariff tool. The tariffs analyzed in this research are based on the annual tool as provided by the developers although it also shows the projected tariffs over a span of six years. As explained at the beginning of this report, an MS Excel model based on a cost-plus approach is used to establish mini-grid tariffs.

After a thorough review of the tariff calculator model, benchmarked against how Nigeria uses its tool in practice, as well as industry standards, the following conclusions can be made about the tool used in Sierra Leone:

1. The tariff tool has no obvious areas to improve calculations.
2. The tool is not easy for an inexperienced user to review/follow. It requires the regulator to develop adequate capacity for specialists to be able to review the tariff applications. The regulator will therefore need to devise a simplified way of conducting a high-level check of the tariff model inputs and outputs.
3. Alternatively, the regulator may want to re-examine if the tariff uses all the details requested in the model and if not then simplify it to broader categories that provide broader classification and functionalization of costs – this will amalgamate some of the details requested in the current tools, reduce the burden of providing details that can be aggregated, improve the audit of inputs into the model, and simplify the reviewing process for the regulatory staff.
4. The drop-down menu in the assets input tab will not make it easy for the regulator to make comparisons of "like for like", when it wants to come up with benchmarks. A more prescriptive listing in the tool is required that is aligned to the benchmark headings.
5. The developers' feedback suggests that the tool does not provide for adjustment for inflation and currency depreciation over the MYTO period: *"A particular challenge right now is the massive deviation in inflation and local currency depreciation from the MYTO assumptions, and the lack of a process for adjusting this effectively, and that the MYTO tool is not really well reflected in the regulations."*[41]

[41] Sierra Leone mini-grid operator, January 2023

PART THREE

Conclusion

There are a range of interventions beyond subsidies that should be explored to bring down tariffs in Sierra Leone, affecting affordability sustainably and in the long term. Some are regulatory and policy driven while others — like efficiency improvements and deployment of new proven technologies for optimal performance — are operational on the part of developers. In addition, in order to have an impact, the recommendations should be seen as a package rather than as standalone measures. Capex and unutilized capacity coupled with service territory allocation should be prioritized to reach economies of scale. The service territory allocation should also consider combining profitable and non-profitable sites to enable cross-subsidization for mini-grids to be commercially viable. Programmes supporting productive use of energy (PUE) such as appliance financing in parallel with tariff reduction strategies should be encouraged for piloting to explore the possibility of increasing the load for these mini-grids and improve their commercial viability. In addition, the developers propose simplifying contractual management in work package 1 (WP-1) for efficiency to reduce assets management costs that are driving up tariffs as well as re-evaluation of the major maintenance reserve account (MMRA) payment amounts under the subsidy issue.

Finally, the drive for lower tariffs should not be just about providing subsidies to the developers. There should be convergence upfront, before giving subsidies, between stakeholders on a mini-grid tariff that is affordable for the community and acceptable to both the private and public sector. The difference between the mini-grid tariff and the cost-reflective tariff is then covered by a sustainable smart subsidy.

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21 Annex

21.1 KEY TAKEAWAYS FROM SEFORALL'S 2021 REPORT ON MINI-GRID TARIFFS IN SIERRA LEONE AND NIGERIA

Tariff calculation methodology:

- The multi-year tariff order (MYTO) tool reduces the regulatory burden for developers and regulators.
- In Nigeria, registered mini-grids have the flexibility to set their tariffs freely and/or to use the tariff calculation tool.

Main similarities and differences between the tariff frameworks in Sierra Leone and Nigeria:

- The annual total allowed revenue used in tariff determination for Sierra Leone and Nigeria has certain components unique to each that could drive differences in tariffs for similar installations.
- The developer is allowed to calculate its return on the regulated asset base (RAB), subject to approval by the Sierra Leone Electricity and Water Regulatory Commission (SLEWRC), allowing for potentially differing tariffs as the return on the RAB is based on the local lending rate and the return on equity proposed by the project developer.
- In Sierra Leone, as operators begin to connect more customers and bring larger mini-grid systems online, project development costs are gradually decreasing.
- In both countries, some mini-grid developers charge productive users a lower tariff than residential customers to incentivize the productive use of energy (PUE).
- Access to finance is a key barrier for mini-grid developers in both countries; in Nigeria, developers have built up their internal capacity/expertise (under the Nigeria Electrification Project (NEP)) in terms of preparing proper documentation, thus improving access to financing programmes, and in turn enabling the reduction of tariffs

Ability to reduce capital expenditure (Capex) development and/or operational expenditure (Opex) costs:

- Develop sites at scale, as the economies of scale in developing multiple mini-grid sites at once should reduce some costs (fixed costs are spread over far larger volumes of kWh sold).
- Focus on optimal cost per kWh and the appropriate financing structures for this, as significantly increasing the customers/sites managed and the consumption per customer remains the best way to reduce tariffs[42].

[42] Increasing Energy Access in Sierra Leone, SEforALL

21.2 LICENSED MINI-GRID OPERATORS IN SIERRA LEONE

The SLEWRC has listed on its website five mini-grid operators' licenses as being current/ valid. However, Solar Era has since transitioned to become an independent power producer (IPP). The following table shows the current mini-grid operators in Sierra Leone. It is possible that some of these operators have more than one operational mini-grid.

LICENSE HOLDER	WINCH ENERGY (SL)	OFF-GRID POWER (OGP/POWERGEN)	ENERGICITY (SL) (POWER LEONE)	POWER NED (SEE NOTE 1 BELOW)
LICENSE NUMBER	EWRC/GL/IPP/007	EWRC/GL/IPP/008	EWRC/EMGL/ FULL/10	EWRC/GL/IPP/011
REGION LICENSED	Koinadugu, Falaba, Bombali, Tonkolili	Pujehun, Kailahun, Bo, Bonthe, Kono, Kenema,	Moyamba, Kambia, Portloko	Yele Community, Gbonkonlenkeh Chiefdom, Tonkolili District
LICENSED ACTIVITIES	Electricity generation, Distribution and supply license (photovoltaic mini-grid)	Electricity generation, Distribution and supply license (photovoltaic mini-grid)	Electricity generation, Distribution and supply license (photovoltaic mini-grid)	A generation hydro power with turbines installation with power poles, overhead powerline connectors, and transformers for meter distribution line (Hydro mini grid)
FIRST ISSUE DATE	05.03.2018	28.05.2019	28.05.2019	details not shown
CURRENT ISSUE DATE	01.11.2020	01.11.2020	24.06.2021	details not shown
EXPIRY DATE	31.10.2030	31.10.2040	30.05.2041	details not shown

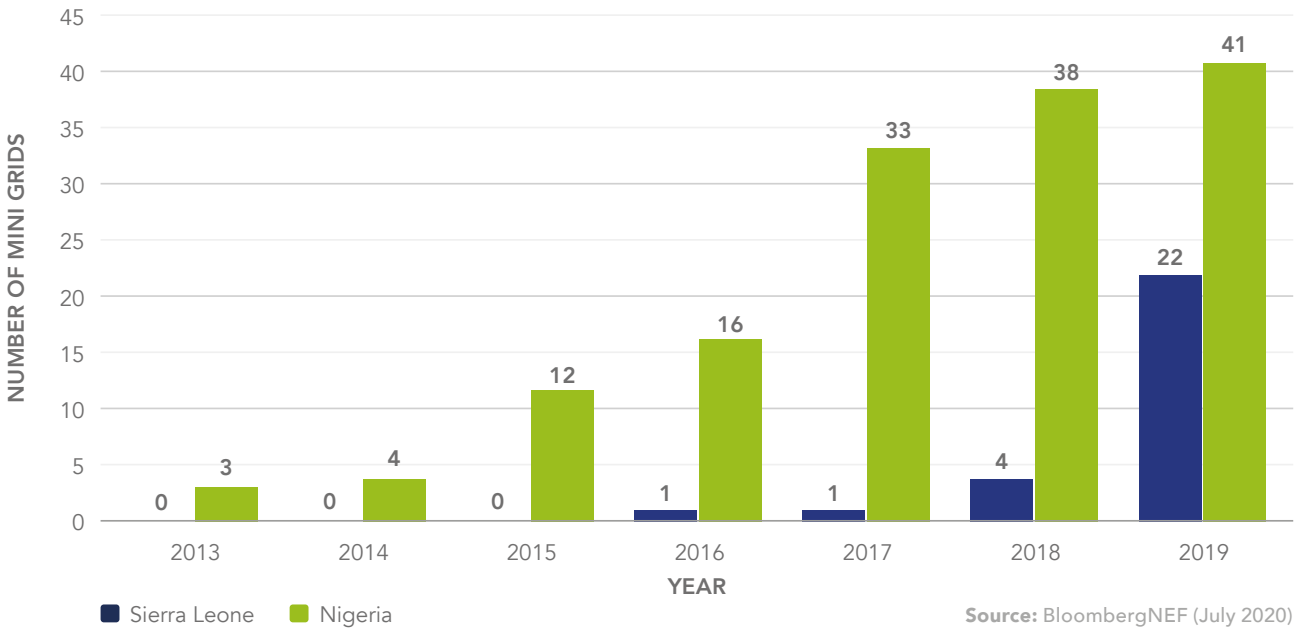
Source: https://ewrc.gov.sl/wp-content/uploads/2021/10/Public-Register-Electricity.pdf.

Note 1: PowerNed Ltd is a single site mini-grid utility service provider, providing electricity to the Yele community, Gbonkonlenkeh Chiefdom, Tonkolili District. The project is supported by Energy4Impact and is operating on hydro power generation with turbines installed with power poles, overhead powerline connectors and transformers for meter distribution line. PowerNed is operating with pre-paid and post-paid meters[43].

[43] Source: SLEWRC Annual Report 2020

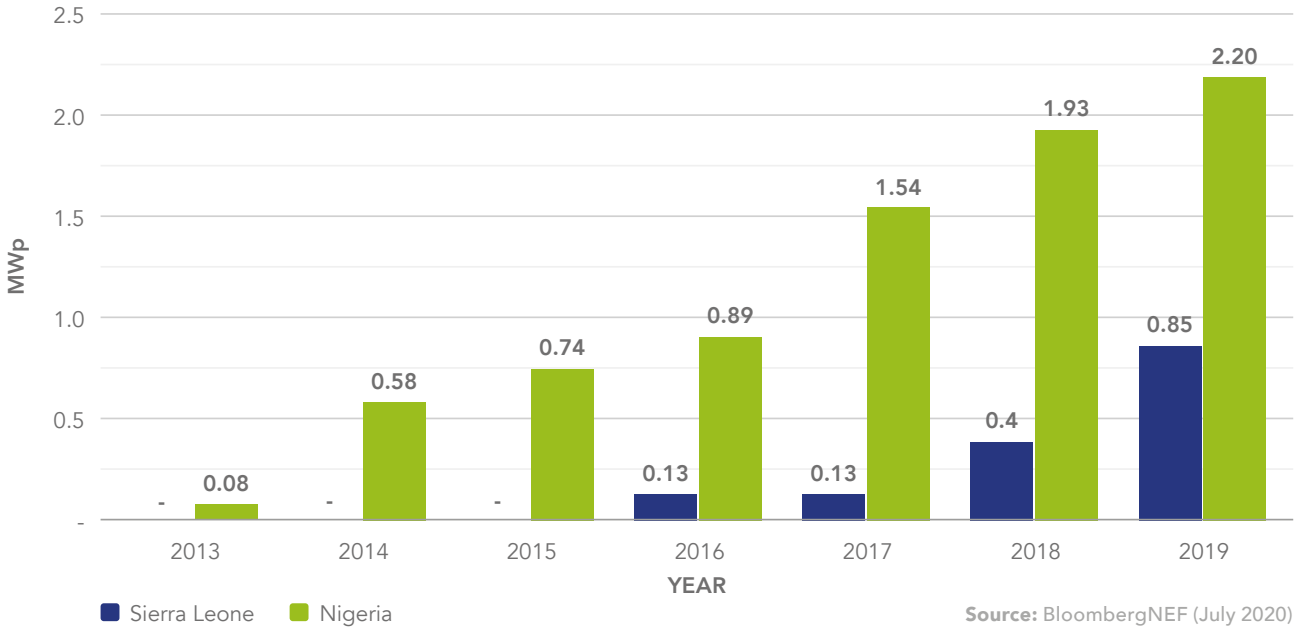
21.3 NUMBER OF MINI-GRIDS AND INSTALLED CAPACITY IN SIERRA LEONE VS NIGERIA

Sierra Leone vs. Nigeria Number of Mini-Grids



Source: BloombergNEF (July 2020)

Sierra Leone vs. Nigeria Installed Capacity (MWp)



Source: BloombergNEF (July 2020)

21.4 HOW REGULATORS DETERMINE TARIFFS IN SIERRA LEONE AND NIGERIA

21.4.1 SIERRA LEONE

The tariff tool is an MS Excel tariff tool applicable to full mini-grids with more than 100kW aggregated installed capacity. In addition to using the tool, the additional documents required to accompany a tariff application are prescribed in Regulation 59 and listed in the tariff approval application form as a requirement.

The tariff tool is underpinned by the cost of service (rate or return methodology) methodology hence the tool calculates the tariff from revenue requirement that is a summation of:

REVENUE REQUIREMENT =
(rate of return x RAB) + D + O&M + (Performance Related Profit Margin (SLL/kWh) x Electricity sold)

Where:
***RAB** means the regulated asset base (Capex)*
***D** means the depreciation of the RAB (Capex)*
***O&M** means the operating and maintenance expenses*

Sierra Leone had been using an annual tool until July 2021 when it changed to a five-year MYTO.

In processing the tariff application, SLEWRC conducts a prudency test followed by community engagement. During the community engagement, the consumers affected by the tariff are given an opportunity to be heard and the applicant makes a presentation in this meeting in support of their application. The applicant may respond to any questions and clarifications sought.

After the regulator makes a tariff decision, it publishes it in the government press and on the commission's website. The regulator communicates the decision to the applicant. In the case of a rejection, the regulator communicates the acceptable rates and the reasons for these rates along with the decision and provides alternative methods/model calculation to the operators.

It is possible to have one tariff for multiple locations. The tariff varies according to the region and the costs that the developer incurs.

21.4.2 NIGERIA

The mini-grid tariff tool used in Nigeria is similar to that used in Sierra Leone and was developed by the same consultant. It is an MS Excel model. The regulation of mini-grids is anchored on the Nigerian Electricity Regulatory Commission (NERC) Regulations for Mini-Grids 2016 issued in term S.96 of the Act (EPSR Act 2005). The annexure to these regulations contains the five-year MYTO tool. The NERC tool is an MS Excel tariff tool applicable to mini-grids with installed capacity of between 100kW and 1MW.

Like Sierra Leone, the tariff tool is based on the cost of service (rate or return methodology) methodology. The tool calculates the tariff from revenue requirement, where:

REVENUE REQUIREMENT =
operational cost + depreciation + return + performance related margin + payments to DisCo (Distribution Company)

When the NERC receives the application, it reviews the tariff model and assesses the costs to see if what the developer has proposed is reasonable. If the costs are too high, the developer approaches the Rural Electrification Agency (REA) for grants, provided either through the Rural Electrification Fund (REF) or the Nigerian Electrification Project (NEP) financed by the World Bank, to subsidize the tariffs. It should be noted that the NERC is not part of the consultation between the community and the mini-grid developer that culminates in the agreed tariff for which the developer is seeking approval.

With respect to batch or portfolio tariff processing the developer must have a tariff for each site. However, if the developer wants an average tariff they can have it, but any compensation when the grid arrives (from DisCo) is assessed for each individual site and not on a portfolio basis.

The mini-grid tariff processing period is about 30 days from the date the regulator receives a complete tariff application. The cost of submitting/processing the tariffs is borne by the mini-grid operators and is part of their development costs.

21.5 METHODOLOGY OF CONDUCTING THE SIERRA LEONE TARIFF RESEARCH

The methodology to undertake this study combines: (a) a participatory consultative approach and (b) evidence-based approach. Figure 6 illustrates these two elements of the approach:

FIGURE 6
Approach Schematic

The participatory consultative approach

This aspect entails holding meetings with the key stakeholders of the assignment to: develop a common understanding of the scope of work, the focus areas and any other project dependencies; agree on the approach to deliver this assignment; capture their respective stakeholders' expectations; agree on how those expectations will be met in the execution of the projection; leverage their contacts to execute the work; and share any other insights that will add value to the work. The stakeholders will also share information on any other ongoing or upcoming projects that will have synergies with this assignment. The stakeholders' consultation will confirm project governance going forward. These key stakeholders are internal stakeholders from Sustainable Energy for All (SEforALL) including the project manager, the CEO, the Phase 1 project lead among others as well as external project stakeholders that include the UN Office for Project Support (UNOPS) and the Foreign, Commonwealth and Development Office (FCDO) among others. UNOPS is a key stakeholder for sharing data required for the analysis.

Evidence-based approach

In the evidence-based approach, SEforALL will use secondary existing reports as well as conduct a comparative analysis of the Sierra Leone mini-grid tariffs with one other regional country. It will seek to build on its 2021 FCDO-funded work on *Increasing Energy Access in Sierra Leone*. This is referenced as Phase 1 report findings. In this regard, the focus will be on the findings pertinent to the lessons learned in the deployment of mini-grids to increasing energy access and specifically on matters related to tariffs, settlements, ability and willingness to pay.

A framework of parameters to be compared will be developed to guide that comparative analysis. The scope of work has identified some of these parameters to be: 1) weighted average cost of capital (WACC), 2) cost of labour, 3) logistics, 4) procurement & contracting. SEforALL will examine whether this list should be extended for a more complete analysis.

The comparative analysis of tariffs with one other country will consider, among others, the following:

1. The methodology for revenue requirement – ordinarily the revenue requirement based on the cost of service (rate of return) is applied. This is an additive approach of all cost elements.
2. The capital costs – this will evaluate whether mini-grid assets are of similar specifications, similar costs and similar economic useful lives.
3. Subsidies – the levels of subsidies provided to comparators.
4. The operating and maintenance (O&M) expenses of comparators.
5. The allowed return on investment to comparators.
6. The level of value-added tax (VAT) and import duties of comparators.
7. The regulatory compliance costs of comparators.
8. Other comparative parameters mentioned in the scope of work.

Comparison will also be made on tariff structuring and payment options to see if they have any impact on access and affordability for the customers. Finally, an inquiry will be made to establish if there are "informal" tariff caps that developers think regulators will not approve that lead them to try to keep their tariffs within that "informal" cap.

21.6 RREP WORK PACKAGES

WP-1 AND 1+	6kWp solar photovoltaic (SPV) generation facilities installed at 54 community health centres (CHCs) Expanded to a capacity > ~36kW of the 50 of the previously constructed CHC solar power stations and installed distribution networks throughout each village, creating independent mini-grids. These distribution networks would extend electricity access to houses, schools and businesses in the various villages. The mini-grids are operated by private operators with commercial interests thus ensuring long-term sustainability.
WP-2	A further 44 mini-grid installations with a capacity of >36kW through co-investment with the private sector operators.
WP-3	Technical assistance and institutional support (capacity building) to the government and the private sector, to facilitate an enabling environment for mini-grid development and long-term sustainable operations.
WP-5	Monitoring and evaluation (M&E) and communications.
WP-6	Strengthen and promote productive use of energy (PUE) in mini-grid areas to contribute to the local economy and social growth for the communities and ultimately increase the welfare of the supported communities.
WP-7	Tariff subsidy for non-generation assets and elimination of public reserve account payments. Through this work package, additional funds will be used to procure non-generation assets (electricity meters and indoor connection materials, e.g. sockets), and to eliminate public reserve account payments by the operators for the first four years of the project.

Source: http://www.energy.gov.sl/home/rural-renewable-energy-project/; http://www.energy.gov.sl/Rural_Renewable_Energy_Programme.html

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DISCLAIMER

This publication is a study prepared by Sustainable Energy for All (SEforALL). The information contained in this report is based on stakeholder interviews and input data from existing mini-grids in both Sierra Leone and Nigeria. All reasonable precautions have been taken by the authors of the report to verify this information as well as protect the anonymity and attribution of specific data points as per data sharing agreements. However, they do not guarantee its accuracy or completeness, as it may be subject to change without notice. This publication has been prepared as a general guidance and the findings and recommendations do not necessarily reflect the views of SEforALL.

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About SEforALL

Sustainable Energy for All (SEforALL) is an independent international organization that works in partnership with the United Nations and leaders in government, the private sector, financial institutions, civil society and philanthropies to drive faster action on Sustainable Development Goal 7 (SDG7) – access to affordable, reliable, sustainable and modern energy for all by 2030 – in line with the Paris Agreement on climate change.

SEforALL works to ensure a clean energy transition that leaves no one behind and brings new opportunities for everyone to fulfil their potential. Learn more about our work at www.SEforALL.org.